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CONTENTS

William Gilson Farlow ..... G. P. Clinton 1
Studies with macrosporium from tomatoes ..... J. Rosenbaum 3
Causes for the production of pathological xylem in the injected trunks of chestnut trees ..... Carolyn Rumbold 29
The mosaic disease of the solanaceae, its relation to the phloem-necrosis, and its effect upon potato culture ..... H. M. Quanjer 35
Raising phloem-necrosis and mosaic tree potatoes, and a source of infection whose nature has not yet been elucidated ..... J. Oortwijn Botjes 45
Phytopathological notes 51
Phytopathology abstracts 60
Literature on plant diseases 66

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CONTENTS OF VOLUME X

No. 1. January

William Gilson Farlow. G. P. Clinton 1
Studies with Macrosporium from tomatoes. J. Rosenbaum 9
Causes for the production of pathological xylem in the injected trunks of chestnut trees. Caroline Rumbold 23
The mosaic disease of the Solanaceae, its relation to the phloem-necrosis, and its effect upon potato culture. H. M. Quanjer 35
Raising phloem-necrosis and mosaic free potatoes, and a source of infection whose nature has not yet been elucidated. J. Oortwyn Botjes 48
Phytopathological notes 50
Phytopathological abstracts 51
Literature on plant diseases 69

No. 2. February

A bacterial leafspot of velvet bean. Frederick A. Wolf 73
Heart rot, rib rot, and leaf spot of Chinese cabbages. Nellie A. Brown and R. B. Harvey 81
A nematode disease of red clover and strawberry in the Pacific Northwest. L. P. Byars 91
Streak disease of potato. W. A. Orton 97
Infection experiments on tomatoes with Phytophthora terrestria Sherb. and a hot water treatment of the fruit. J. Rosenbaum 101
Briefer articles:
Phony peaches: a disease occurring in middle Georgia. David C. Neal .. 106
Phytopathological notes 111
Literature on plant diseases 112

No. 3. March

Bacterial blight of soybean. Frederick A. Wolf 119
Some insect relations of Bacillus tracheiphilus Erw. Sm. Frederick V. Rand and Lillian C. Cash 133
Notes on some diseases of aspen. Carl Hartley and Glenn G. Hahn 141
Iris leaf spot caused by Didymellina iridis. W. B. Tisdale 148
Three winter wheat varieties resistant to leaf rust in Kansas. Leo E. Melchers and John H. Parker 164
Briefer articles:
The distribution of buckeye rot of tomatoes. J. L. Weimer 172
Varietal susceptibility to false blossom in cranberries. S. B. Fracker 173
Observations on seed transmission of the cabbage black rot organism. J. C. Walker and W. B. Tisdale 175
Results of white pine blister rust control in 1919. S. B. Detwiler 177
Literature on plant diseases 181

388169

Contents

No. 4. April

Samuel McCutchen Bain. S. H. Essary 185
A coördination of our knowledge of insect transmission in plant and animal diseases. Frederick V. Rand and W. Dwight Pierce 189
The Phyllosticta blight of snapdragon. Edwina M. Smiley 232
Phomopsis juniperovora, a new species causing blight of nursery cedars. Glenn Gardner Hahn 249
Phytopathological notes 254
Literature on plant diseases 259
Appendix—Report of the eleventh annual meeting of the American Phytopathological Society 264

No. 5. May

Observations on some common and important diseases of the Rhododendron. Henry Schmitz 273
Facultative heteroecism in Peridermium cerebrum and Peridermium harknessii. E. P. Meinecke 279
On the amount of copper required for the control of Phytophthora infestans on potatoes. O. Butler 298
Phytopathological notes 305
Literature on plant diseases 309
Appendix—Abstracts of papers read at the Ontario meeting 314

No. 6. June

Peronospora in turnip roots. Max W. Gardner 321
Experiments upon formaldehyde-drip control of onion smut. J. C. Walker .. 323
A new corn smut in Washington. B. F. Dana and George L. Zundel 328
Coix smut. C. C. Thomas 331
Abnormal growth induced by chloral hydrate soil treatment. Carl Hartley. 334
A battery of chambers with different automatically maintained temperatures. B. E. Livingston and H. S. Fawcett 336
Reviews 341
Phytopathological notes 342
Literature on plant diseases 344
Appendix—Report of the meeting at Portland, Oregon 351

No. 7. July

The apple blotch and bitter-rot cankers. John W. Roberts 353
Observations on the distance of spread of aeciospores and urediniospores of Cronartium ribicola. Walter H. Snell 358
Heat injury to beans in Colorado. H. G. McMillan and L. P. Byars 365
Briefer articles:
Note on resistance of chestnut to the blight. J. Franklin Collins 368
Note on the pathological effects of blazing trees. James R. Weir 371
Albert Thomas Bell. C. W. Edgerton 373
Phytopathological notes 375
Literature on plant diseases 377
Appendix—Southern division meeting 381

Contents

No. 8. August

A pestalozzia producing a tumor on the Sapodilla tree. Nellie A. Brown... 383
Briefer articles:
Notes on Peridermium harknessii. George G. Hedgcock and N. Rex Hunt... 395
Pythiacystis and Phytophthora. H. S. Fawcett... 397
Some methods for investigating internal seed infection. J. B. S. Norton and C. C. Chen... 399
Reviews... 401
Phytopathological notes... 402
Literature on plant diseases... 403

No. 9. September

Relation of climate to the development and control of leaf roll of potato. Paul A. Murphy and E. J. Wortley... 407
A Macrosporium foot-rot of tomato. J. Rosenbaum... 415
Briefer articles:
A frost injury of potatoes. H. G. MacMillan... 423
Device for growing large plants in sterile media. J. K. Wilson... 425
Gumming disease of sugar cane in Porto Rico. J. Matz... 429
Literature on plant diseases... 431

No. 10. October

Wilt of white clover, due to Brachysporium trifolii. Lee Bonar... 435
Observations on Cytospora chrysosperma in the Northwest. Ernest E. Hubert... 442
The effect of citric acid on the germination of the teliospores of Puccinia graminis tritici. A. F. Thiel and Freeman Weiss... 448
Briefer articles:
Apple black rot (Sphaeropsis malorum Berk.) in Oregon. C. R. Stillinger. 453
Phytopathological notes... 459
Literature on plant diseases... 460

No. 11. November

Collar-rot of apple trees in the Yakima Valley. J. W. Hotson... 466
A preliminary study of the purple leaf sheath spot of corn. L. W. Durrell.. 487
Phytopathological notes... 496
Literature on plant diseases... 506

No. 12. December

Studies on the rate of growth and behavior of the blister rust on white pine in 1918. Arthur S. Rhoads... 513
A fourth Phytophthora disease of tomato. Donald Reddick... 528
Rhizopus infection of corn on the germinator. J. F. Adams and A. M. Russell 535
Phytopathological notes... 544
Literature on plant diseases... 547

INDEX TO VOLUME X

Abies balsamea, 388
Abnormal growth induced by chloral hydrate soil treatment, 334
Abstracts of papers presented at Eleventh Annual Meeting of the American Phytopathological Society, 51–68; at First Annual Meeting of Canadian Branch, American Phytopathological Society, 314–319
Acer, circinatum, Cytospora on, 443; glabrum, Cytospora on, 443; rubrum, Cytospora on, 443
Achrae sapotae, 391
Achras zapota, 383
Acid, citric, effect on Puccinia graminis tritici, 448
Actinomyces scabies, 63
Adams, J. F., and Russell, A. M., Rhizopus infection of corn on the germinator, 535–543
Advisory Board of American Plant Pathologists, Washington meeting of, 257
Aeciospores of Cronartium ribicola, spread of, 358
Alfalfa, crown wart, 65
Alkali, relation of to collar-rot, 475
Alternaria, fasciculata, 20; solani, insect transmission of, 209; on tomatoes, 59
American Phytopathological Society, report of Eleventh Annual Meeting, 265–271; report of meeting of Pacific Coast Division, 351–352; report of Southern Division meeting, 381; summer field meeting of, 496
Annual general meeting of the Association of Economic Biologists, 254–256
Anthracnose, of sweet peas, transmission of, 198; of vanilla, 341
Aphelenchus cocophilus, 401
Aphids, relation to potato tip burn, 61
Aplanobacter stizolobii n. sp., 75
Apple, bitter rot, insect transmission of, 201; black rot, 453; blotch, spraying for, 58; blotch and bitter-rot cankers, 353; canker, insect transmission of, 197, 208; collar rot, 465; scab, control of, 58; slime flux, 58
Arceuthobium pusillum, 317
Armillaria mellea, 466, 469; on Azalea, 375; on Rhododendron, 375
Arsenical poisoning, 466, 474, 477
Arthur, J. C. Two destructive rusts ready to invade the United States (abst.), 65
Ash, mountain, see Sorbus
Aspen, diseases of, 141; trunk troubles of, 143; twig troubles of, 143; see also Populus
Atwood, Alice C., and Smith, Florence P. Literature on plant diseases, 69–71, 112–117, 181–184, 259–263, 309–313, 344–350, 377–380, 403–405, 431–434, 460–464, 506–512, 547–554
Azalea, shoe-string rot of, 375

Bacillus, amylovorus, 466; amylovorus, insect transmission of, 192; cloacae, 490; coli, 494; coli, insect transmission of, 214; subtilis, 494; tracheiphilus, insect relations of, 133; tracheiphilus, insect transmission of, 210
Bacterial blight of soybean, 68, 119
Bacterium, aptatum, insect transmission of, 203; campestre, 82; campestre, insect transmission of, 195; malvacearum, insect transmission of, 203; savastanoi, insect transmission of, 212; sojae, 79, 120; solanacearum, insect transmission of, 195; tumefaciens, 387
Bain, Samuel McCutchen, biographical sketch of, 185
Banana wilt, 504
Barley, leaf spot, 317; resistance of to Rhynchosporium, 54; stem disease, 317; streak, 317

Basidia, shape of, in Uredineae and Hymenomycetes, 315
BEACH, F. H., see STOVER, W. G.
Bean, heat injury to, 365; inheritance of disease resistance in, 319; mosaic, 317
Beet, leaf spot, insect transmission of, 203
Beetle, scolytid, relation to white pine blister rust, 524
BELL, ALBERT THOMAS, biographical sketch of, 373
BENNETT, C. W., Phoma root-rot of celery (abst.), 67
Berberis canadensis, Puccinia graminis on, 305
BIGGAR, H. HOWARD, see HOLBERT, J. R.
Biographical sketch of, Bain, Samuel McCutchen, 185; Bell, Albert Thomas, 373; Farlow, William Gilson, 1; Kawakami, Koichiro, 459
Biologists, economic, annual general meeting of the association of, 254
Bitter-rot cankers, apple, 353
Black leg, cabbage, occurrence and control of, 64
Black rot, apple, 453; cabbage, seed transmission of, 175
BLAIR, R. J., Decay in the timber of pulp and paper mill roofs (abst.), 314; Wood-destroying fungi in pulp and paper mill roofs (abst.), 61
Blazing trees, pathological effect of, 371
Blight, cedar, 249; chestnut, insect transmission of, 201; early, on tomato fruit, 9; resistance of chestnut to, 368; snapdragon, 232
Blister rust, white pine, 177; behavior of pycnia and aecia of, 515
Blossom blight, peach, 64
Blotch, apple, 353
Blue grass, rusted appearance, 317
Boll disease, internal, of cotton, transmission of, 198
BONAR, LEE, Wilt of white clover due to Brachysporium trifolii, 435–441
BOTJES, J. OORTWYN, Raising Phloem-necrosis- and mosaic-free potatoes, and a source of infection whose nature has not yet been elucidated, 48–49
Botrysphaeria ribis, insect transmission of, 198
Botrytis sp., 317, 533; on tomatoes, 498; cinerea, insect transmission of, 203; vulgaris, insect transmission of, 203
Brachysporium trifolii n. sp., 441
Brassica, chinensis, heart rot of, 81; pekinensis, heart rot of, 88
Brazil nuts, black crust, 61
BRENTZEL, W. E., see REDDY, C. S.
Brome grass, powdery mildew, insect transmission of, 204
BROWN, FLORENCE COERPER, see WOODWORTH, C. M.
BROWN, NELLIE A., A Pestalozzia producing a tumor on the Sapodilla tree, 383–394; and Harvey, R. B., Heart rot, rib rot, and leaf spot of Chinese cabbage, 81–90.
Brown rot of lemon, 397
BULLER, A. H. R., Some comparative observations upon the shape of the basidia and the mode of spore discharge in the Uredineae and the Hymenomycetes (abst.), 315; The pseudorhiza of certain saprophytic and parasitic Agaricineae (abst.), 316
Bunt, of wheat, 53
BUTLER, O., On the amount of copper required for the control of Phytophthora infestans on potatoes, 298–304
BYARS, L. P., A disease of red clover and strawberry in the Pacific Northwest caused by the nematode Tylenchus dipsaci (Kühn), Bastian (abst.), 66; A nematode disease of red clover and strawberry in the Pacific Northwest, 91–95; see also MacMillan, H. G.

Cabbage, black leg, insect transmission of, 197; black leg, occurrence and control of, 64; black rot, insect transmission of, 195; black rot, seed transmission of, 175; Fusarium-resistant, 64; yellows, influence of soil temperature on, 63
CAESAR, L., Some data on peach yellows and little peach in Ontario (abst.), 318
Canada balsam, witches broom of, (abst.), 315

Canker, blister, of apple, 58; caused by Cytospora, 442
Carnation bud rot, insect transmission of, 196
CARR, R. H., see HOFFER, G. N.
CASH, LILLIAN C., see RAND, F. V.
Castanea, resistance of, to blight, 368
Cedar, Phomopsis blight, 249
Celery, Phoma root-rot, 67
Cephalothecium roseum, 538
Cercospora, beticola, insect transmission of, 203; medicaginis, 66; personata, insect transmission of, 208
Cereal rusts, 319
Check list of Department of Agriculture publications, 256
Chemicals, effect on vascular system of injected chestnuts, 23; injection into vetch seedlings, 30; stimulation of cells by, 29
CHEN, C. C., see NORTON, J. B. S.
Cherry, leaf spot, 317; shot hole, 317
Chestnut, blight cankers, healing of, 370; blight, insect transmission of, 201; pathological xylem produced by injection of chemicals, 23; resistance to blight, 368
Chinese cabbage, heart rot, 81; leaf spot, 81; rib rot, 81
Chloral hydrate, soil treatment with, 334
Citric acid, effect on Puccinia graminis tritici, 448
Citrus, Phytophthora terrestria on, 397
Claviceps purpurea, insect transmission of, 208
CLAYTON, E. E., The relation of soil temperature to the development of the tomato Fusarium wilt (abst.), 63
Climate, relation of to the development and control of leaf roll of potato, 407
CLINTON, G. P., William Gilson Farlow, biographical sketch, 1–8
Clitocybe parasitica, 466
Clover, bur, leaf-spot, overwintering and control of, 66; red, nematode disease of, 66; white, wilt of, 435
Cocoanut, bud rot, insect transmission of, 214; root disease, 401
Coccomyces, dentatus, 276; hiemalis, 317; prunophorae, 317
Coix, smut, 331
Collar rot of apple trees in the Yakima Valley, 465
Colletotrichum falcatum, insect transmission of, 203
COLLINS, J. FRANKLIN, Note on resistance of chestnut to blight, 368–371
Conifers, resinous species of, 372; nonresinous species of, 372; infection of through mechanical wounding, 371
Coniothyrium caryogenum, 199
COOK, MEL T., The Alternaria fruit rot and Rhizoctonia stem rot of tomatoes (abst.), 59; Blossom blight of the peach (abst.), 64
COONS, G. H., Experiments on the control of stinking smut of wheat (abst.), 54
Copper, amount required for control of potato Phytophthora, 298
Coriolus versicolor, 65
Corn, new smut in Washington, 328; purple leaf sheath spot, 54, 487; results with inoculated seed, 57; Rhizopus infection of, on the germinator, 535; root rot, control of, 55; stalk rot, control of, 55; tests with diseased and healthy seed, 57
Coryneum rhododendri, 276
Cotton, angular leaf spot, insect transmission of, 203; anthracnose, insect transmission of, 203; internal boll disease, insect transmission of, 198
Cottonwood, see Populus
Cranberries, false blossoms in, 173
CROMWELL, RICHARD O., Recent studies on Septoria of wheat (abst.), 51
Cronartium, coleosporoides, 395; ribicola, distance of spread of aeciospores and urediniospores of, 358; ribicola, insect transmission of, 209; ribicola, on Ribes cynosbati, 359, on Ribes rotundifolium, 361, on R. Americanum, 361; ribicola, production of aecia of, 111
Crop protection institute, 544
Crown rot of apple, 465
Crown wart, alfalfa, 65
Cryptostictis sp., 277

Cucumber, bacterial wilt, insect transmission of, 210; mosaic, 317; mosaic, insect transmission of, 218
Cucurbit, bacterial wilt, insect transmission of, 210
Culture, pure, device for growing large plants in sterile media, 425
Curly dwarf, potato, 36
Currant, cane blight, insect transmission of, 198; and white pine blister rust control, 177
Cydonia vulgaris, 391
Cytospora chrysosperma, 442

Dana, B. F., and Zundel, George L., A new corn smut in Washington, 328–330
Dasyscypha calycina, insect transmission of, 196
Detwiler, S. B., Results of white pine blister rust control in 1919, 177–180
Dickson, B. T., Sclerotinia wilt of greenhouse tomatoes, 500–501; Stem-end rot of greenhouse tomatoes, 498–500
Dickson, James G., see Holbert, J. R.; see Johnson, A. G.
Didymellina iridis, 148
Diorchidium spp., insect transmission of, 209
Disease resistance, inheritance of in bean, 319; of barley varieties to Rhynchosporium, 54
Disease transmission by insects, 189
Drayton, F. L., Health and disease in plants, 314
Drechsler, Charles, see Jones, Fred Reuel
Durrell, L. W., The purple sheath spot of corn (abst.), 54; A preliminary study of the purple leaf sheath spot of corn, 487–495

Echinodontium tinctorium, 372
Edgerton, C. W., Albert Thomas Bell, biographical sketch, 373–374
Egg plant, resistant in wilt-infected soil, 59; wilt, 317
Endothia parasitica, insect transmission of, 201; on chestnut, 368
Ergot, insect transmission of, 205, 208
Errata, 343
Erysiphe graminis, insect transmission of, 204
Essary, S. H., Samuel McCutchen Bain, biographical sketch, 185–188
Euphorbia flagellosis, insect transmission of, 215
Exoascus unilateralis, 317

False blossom in cranberries, 173
Farlow, W. G., Biographical sketch of, 1
Faull, J. H., Needle blight of white pine (abst.), 315
Fawcett, H. S., Pythiacystis and Phytophthora, 397–399; see also Livingston, B. E.
Field meeting of American Phytopathological Society in 1920, 496
"Filterable virus" diseases, insect transmission of, 219
Fir, balsam, butt rots of, in Quebec Province (abst.), 314
Fire blight, of apple in Washington, 465; insect transmission of, 192, 193, 200
Flax, canker, a non parasitic disease, 66
Fomes, igniarius, 143; laricis, 372; pinicola, 314, 372
Footrot, of citrus, 398; of tomato, Macrosporium, 415; of wheat, 52
Forest trees, Cytospora on, 442
Formaldehyde-drip control of onion smut, 323
Fracker, S. B., Varietal susceptibility to false blossom in cranberries, 173–175
Fragaria, nematode disease of, 91
Fraser, W. P., A smut of western rye grass (abst.), 316
Fromme, F. D., The development of loose smut of wheat as modified by soil fertility (abst.), 53
Frost injury of potatoes, 423
Fungi new to Ontario, 317
Fusarium, avenaecium, on wheat, 51; cabbage resistant to, 64; corn rot, 55; cubense, 504; culmorum on corn, 494; culmorum on wheat, 51; hyperoxysporum, 306; lycopersici, 63, 306; pea blight, 67; the effect of temperature and light on, 52; tomato, influence of soil temperature on, 63

Fusicladium effusum, insect transmission of, 205

GARDNER, MAX W., Peronospora in turnip roots, 321–322
Gibberella saubinetii, on corn, 55, 57; on wheat, 51
Gloeosporium vanillae, 341
Glomerella, cingulata, 353; cingulata, insect transmission of, 201
GLOYER, W. O., Apple blister canker, 58; Effect of straw mulch on potato leaf roll (abst.), 60
GODFREY, G. H., A seed-borne Sclerotium and its relation to a rice-seedling disease, 342–343
Gooseberries and white pine blister rust control, 177
Grape root disease, insect transmission of, 207, 214
Growth, rate of, of blister rust on white pine, 516
Gumming disease of sugar cane in Porto Rico, 429
Gummosis, 397

HAHN, GLENN G., Phomopsis juniperovora, a new species causing blight of nursery cedars, 249–253; see also HARTLEY, CARL
HARTLEY, CARL, Abnormal growth induced by chloral hydrate soil treatment, 334–335; and HAHN, GLENN G., Notes on some diseases of aspen, 141–147
HARTER, L. L., and WEIMER, J. L., Sweet potato stem rot and tomato wilt, 306–307
HARVEY, R. B., see BROWN, NELLIE A.
Head smut, corn, 328
Health and disease in plants (abst.), 314
Heart-rot, peach, 65
Heat injury to beans, 365
HEDGCOCK, GEORGE G., and HUNT, N. REX, Notes on Peridermium harknessii, 395–397
Helminthosporium, avenae-sativae, 317; sativum, 317, 494; teres, 317
Heteroecism, facultative, 279
Heterosporium gracile, 153
HOFFER, G. N., and CARR, R. H., Iron accumulation and mobility in diseased cornstalks (abst.), 56; and CARR, R. H., Experiments to test effects of iron salts on corn plants (abst.), 57; see also HOLBERT, J. R.
H-ion concentration in diseased corn tissues, 56
HOLBERT, J. R., DICKSON, JAMES G. and BIGGAR, H. HOWARD, Correlation of early growth, variation and productivity of maize as influenced by certain pathogenic factors (abst.), 57; HOLBERT, J. R., and HOFFER, G. N., Corn root and stalk rots (abst.), 55
Hopperburn, potato, 61; potato, insect transmission of, 220
HOPKINS, E. F., Overwintering and control of bur clover leaf-spot (abst.), 66
HOTSON, J. W., Collar rot of apple trees in the Yakima Valley, 465–486
HOWITT, J. E., Some observations made in inspecting for leaf roll and mosaic (abst.), 316; see also STONE, R. E.
HUBERT, ERNEST E., Observations on Cytospora chrysosperma in the northwest, 442–447
HUNGERFORD, CHAS. W., and WADE, A. E., Relation between soil moisture and bunt infection in wheat (abst.), 53
HUNT, N. REX, see HEDGCOCK, GEORGE G.
Hydnum, 372
Hymenomycetes, shape of basidia and mode of spore discharge in, 315

Insect relations of Bacillus tracheiphilus, 133
Insect transmission of diseases, 189
Institute, crop protection, 544
Instruments, scientific and patent rights, 67
Iris leaf spot, 148
Iron, in diseased cornstalks, 56
Iron salts, effects, in corn tissues, 57
Ithyphallus coralloides, insect transmission of, 207

JOHANN, HELEN, see JOHNSON, A. G.
JOHNSON, A. G., DICKSON, JAMES G., and JOHANN, HELEN, An epidemic of

Fusarium blight (scab) of wheat and other cereals (abst.), 51; JOHNSON, A. G., and MACKIE, W. W., Evidence of disease resistance in barley to attacks of Rhynchosporium (abst.), 54
JOHNSTON, JOHN R., Review of Les Vanillieres de Tahiti et Moorea by E. P. Meinecke, 341–342.
JONES, FRED REUEL, Pythium as a causal factor in pea blight (abst.), 67; and DRECHSLER, CHAS., The development of Urophlyctis alfalfae (abst.), 65
JONES, L. R., and MCKINNEY, H. H., The influence of soil temperature on the development of potato scab (abst.), 63; JONES, L. R., WALKER, J. C., and TISDALE, W. B., Fifth progress report on Fusarium-resistant cabbage (abst.), 64
Juniperus virginiana, blight of, 249

KAWAKAMI, KOICHIRO, biographical sketch of, 459
KEITT, G. W., A preliminary report on apple scab and its control in Wisconsin (abst.), 58
KOTILA, J. E., Leaf hoppers and hopperburn of potato leaves (abst.), 61
KRAKOVER, L. J., see STAKMAN, E. C.

Larch canker, insect transmission of, 196
Larix occidentalis, 389
"Leaf-curl," potato, 35
Leaf hopper, potato, 61
Leaf roll, potato, 35, 407; potato, infection of neighboring plants, 43
Leaf rust, wheat varieties resistant to, 164
Leaf spot, tomato, 60; velvet bean, 73
LEE, H. ATHERTON, biographical sketch of Koichiro Kawakami, 459; and SERRANO, FELICISIMO B., Banana wilt in the Philippines, 504–505
Lentodium tigrinum, 61
Lenzites trabeum, 61
Leptomonas davidi, insect transmission of, 215
Leptosphaeria, coniothyrium, 208; culmorum, 317
Lettuce, bacterial rot, insect transmission of, 195
Lima bean mildew, insect transmission of, 195
Literature on plant diseases, 69, 112, 181, 259, 309, 344, 377, 403, 431, 460, 506, 547
Little peach in Ontario, 318
LIVINGSTON, B. E., and FAWCETT, H. S., A battery of chambers with different automatically maintained temperatures, 336–340
Lophodermium rhododendri, 276
LYMAN, G. R., The 1919 survey of potato wart (abst.); 60; the summer field meeting of the American Phytopathological Society, 496–498

MCCALLUM, A. W., Napicladium tremulae, a new disease of the poplar (abst.), 318
MCCLINTOCK, J. A., Field tests with strains of wilt-resistant tomato seed in 1919 (abst.), 59
MCCUBBIN, W. A., A heart-rot of peach (abst.), 65
MACINNES, JEAN, The effect of temperature and light on Fusarium sp. causing wheat scab (abst.), 52
MACKIE, W. W., Head smut in sorghum and maize, 307–308; see also JOHNSON, A. G.
MCKINNEY, H. H., see JONES, L. R.
MCLARTY, H. R., A suspected mosaic disease of sweet clover, 501–503
MACMILLAN, H. G., A frost injury of potatoes, 423–424; and BYARS, L. P., Heat injury to beans in Colorado, 365–367
MCROSTIE, G. P., Inheritance of disease resistance in the common bean (abst.), 319
Macrosporium, solani, 15, 17, 59, 418; foot-rot of tomato, 415
Maize, head smut, 307
Mal di gomma, 398
Mangifera indica, 388
Maple, see Acer
Marssonia, populi, 143; potentillae, 317
MARTIN, WILLIAM H., Sulphur experiments for the control of potato scab (abst.), 60

MATZ, J., Gumming disease of sugar cane in Porto Rico, 429–430
Media, sterile, device for growing large plants in, 425
MEINECKE, E. P., Facultative heteroecism in Peridermium cerebrum and P. harknessii, 279–297; report on diseases of vanilla in Tahiti and Moorea, 341
Melampsora, albertensis, 143; medusae, 143
Melampsorella caryaphyllacearum, 315
Melampsoropsis piperiana, 274
Melanconium fungus, insect transmission of, 204
MELCHERS, L. E., The resistance shown by three hard winter wheats, Kanred (P762), P1066, and P1068, to plant diseases (abst.), 52; and PARKER, J. H., Three winter wheat varieties resistant to leaf rust in Kansas, 164–171; and PARKER, JOHN H., The resistance of Kanred (P762), P1066, and P1068, three hard winter wheats to leaf rust (abst.), 52
Monilia candida, insect transmission of, 214
Mosaic, of cucumber, 218; pokeweed, 218; potato, 35, 220; spinach, 219; sweet clover, 501; sweet pea, 218; tobacco, 218; tomato, 218; analogy to phloem-necrosis, 36; tobacco, relation of to mosaic on potato, 42; transmission through embryo, 45
MURPHY, PAUL A., New or little-known diseases of potatoes which cause "running out" of seed (abst.), 316–317; and WORTLEY, E. J., Relation of climate to the development and control of leaf roll of potatoes, 407–414

Nail-head spot of tomato fruit, 9, 59
Napicladium tremulae, 318
Nasturtium, bacterial leaf spot, insect transmission of, 203
NEAL, D. C., Phony peaches: a disease occurring in middle Georgia, 106–110
Nectria, ditissima, insect transmission of, 197; ipomoeae, 317
Nematode, cause of red ring of coconut palms, 401; disease of red clover and strawberry, 66, 91
NORTON, J. B. S., and CHEN, C. C., Some methods for investigating internal seed infection, 399–400
NOWELL, WILLIAM, The red ring or "root" disease of coconut palms (review), 401
Nummularia discreta, 58

Oat, blade blight, insect transmission of, 195; Helminthosporium, 317
Olea europaea, 388
Oleander, bacteriosis, insect transmission of, 213
Olive-knot, insect transmission of, 212
Onion, blight, insect transmission of, 204; smut control, 323
ORTON, C. R., The crop protection institute, 544–545
ORTON, W. A., Streak disease of potato, 97–100

Pacific Division, American Phytopathological Society, report of meeting, 351–352
PARKER, JOHN H., see MELCHERS, L. E.
PARKS, T. H., see STOVER, W. G.
Patent rights and scientific instruments, 67
Pea blight, Pythium, 67
Peach, blossom blight, 64; brown rot, insect transmission of, 195; heart-rot, 65; phony disease, 106; yellows in Ontario, 318
Peanut, leaf spot, insect transmission of, 208; rust, 65
Pear blight, insect transmission of, 192
Pecan, kernel spot, insect transmission of, 199; scale, insect transmission of, 205
Penicillium glaucum, 494
Peony, Botrytis blight, insect transmission of, 203
Peppers, resistant in wilt infested soil, 59
Peridermium, cerebrum, 279; elatinum, 315; harknessii, 279, 395
Peronospora, parasitica in turnip roots, 321; schleideniana, insect transmission of, 204
Personals, 111, 256, 308, 343, 402, 459, 546

Pestalozzia, cydoniae, 391; funerea, 391; gongrogina, 390; guepini, 277, 391; hartigii, 390; sapotae, 391; scirrofaciens, 392; tumefaciens, 390
Phallus impudicus, insect transmission of, 207
Philippines, banana wilt in, 504; plant pathology in, 503
Phloem-necrosis, potato, 35; relation to mosaic of Solanaceae and effect on potato culture, 35; spread by aphids and other insects, 48
Phloem-necrosis-free potatoes, raising, 48
Pholiota adiposa, 372
Phoma, apiicola, 67; oleracea, insect transmission of, 197; root-rot of celery, 67
Phomopsis, juniperovora, 249; thujae, 252
Phony peaches, 106
Phyllosticta, antirrhini, blight of snapdragon, 232; solitaria, 353
Phytopathological notes, 50, 111, 254–258, 305–308, 342–343, 375–376, 402, 459, 496–505, 544–546
Phytophthora, cryptogea, 529; infestans, insect transmission of, 202; infestans on potatoes, copper required for control of, 298; infestans on tomato seedlings, 317; infestans, susceptibility to by potatoes attacked by mosaic and phloem-necrosis, 46; phaseoli, insect transmission of, 195; sp., the cause of tomato stem-girdle, 532; terrestria on citrus, 397; terrestria on tomatoes, 101, 172, 529; terrestria, effect of temperature on, 340
Picea, pungens, 389; excelsa, 390
PIERCE, W. DWIGHT, see RAND, FREDERICK V.
Pine, white, blister rust on in 1918, 513; needle blight of (abst.), 315
Pineapple fruit rot, insect transmission of, 197, 201
Pinus, attenuata, 395; caribaea, 396; contorta, 395; halepensis, 396; jeffreyi, 397; mayriana, 396; palustris, 396; pinea, 396; ponderosa, 395; ponderosa, abnormal growth of, induced by chloral hydrate soil treatment, 334; ponderosa scopulorum, 396; sabiniana, 395; strobus, 390; taeda, 396; virginiana, 396
Plant diseases, in Ontario, 317; literature on, 69, 112, 181, 259, 309, 344, 377, 403, 431, 460, 506, 547
Plant pathology, changes of a decade in, 65; in the Philippines, 503
Plants in sterile media, device for growing, 425
Pleurotus, 466
Plum, brown rot, insect transmission of, 195; leaf spot, 317; shot hole, 317
Pokeweed, mosaic, insect transmission of, 218
Polygonum, formation of wound tissue by mechanical injury, 30
Polyporus schweinitzii, 314, 395
Polystictus versicolor, 466, 469
Poplar, new disease of, 318; see also Populus
Populus balsamifera, Cytospora on, 442; deltoides, Cytospora on, 442; tremuloides, Cytospora on, 442; trichocarpa, Cytospora on, 442
Poria xantha, 61
Potato, "crinkle," 316; culture, effect of on mosaic and phloem-necrosis, 35; curly dwarf, 36; frost injury, 423; hopperburn, 61; late blight, control of, 298; late blight, insect transmission of, 202; leaf curl, 35; "leaf drop," 317; leaf roll, 35, 60, 316; leaf roll, infection of neighboring plants, 43; leaf roll, relation of climate to development and control of, 407; mosaic, 35, 316; mosaic, infection of neighboring plants, 43; mosaic, insect transmission of, 48, 220; mosaic, relation of to mosaic of tobacco, 42; rust, 65; scab, control of, 60; scab, influence of soil temperature on, 63; scab, sulphur experiments on, 60; seed, advice for selecting, 49; streak, 97; tipburn, 61; varieties, senility of, 46; wart, survey of, 60; wilt, 317
Prunus, demissa, Cytospora on, 443; virginiana, 317
Pseudomonas juglandis, insect transmission of, 200

Pseudorhiza of Agaricineae, 316
Puccinia, antirrhini, 317; graminis on native Berberis canadensis, 305; graminis tritici, 52, 448; graminis tritici compacti, 52; triticina Eriks. on wheat, 164
Pythiacystis citrophthora, 397
Pythium debaryanum pea blight, 67

QUANJER, H. M., Mosaic disease of the Solanaceae, its relation to the phloem-necrosis, and its effect upon potato culture, 35–47

RAND, F. V., and CASH, LILLIAN C., Some insect relations of Bacillus tracheiphilus Erw. Sm., 133–140; RAND, F. V., and PIERCE, W. D., A coordination of our knowledge of insect transmission in plant and animal diseases, 189–231
RANKIN, W. H., Butt rots of balsam fir in Quebec Province (abst.), 314–315
Raspberry, fruit rot and wilt, insect transmission of, 209
Red clover, nematode disease of, 91
Red ring of coconut palms (review), 401
REDDICK, DONALD, Scientific instruments and patent rights (abst.), 67; A fourth Phytophthora disease of tomato, 528–534
REDDY, C. S., and BRENTZEL, W. E., Flax canker, a non-parasitic disease (abst.), 66
Report on St. Louis meeting of American Phytopathological Society, 265–271
Resistant varieties, cabbage to Fusarium, 64; soy bean to bacterial blight, 68
Rhizoctonia, stem rot of tomatoes, 59; solani on peas, 67
Rhizopus nigricans, infection of corn on the germinator, 494, 535
RHOADS, ARTHUR S., Studies on the rate of growth and behavior of the blister rust on white pines in 1918, 513–527
Rhododendron, diseases, 273; shoe string rot of, 375
Rhynchosporium secalis on barley and rye, 54
Ribes, and white pine blister rust control, 177; americanum, 361; cynosbati, 359, 360, 361; rotundifolium, 361
Rice, seedling blight, 342
ROBERTS, JOHN W., The apple blotch and bitter-rot cankers, 353–357
"Root" disease of coconut palms (review), 401
Root-rot of corn, 55
ROSENBAUM, JOSEPH, Studies with Macrosporium from tomatoes, 9–21; A stem disease of tomato caused by Macrosporium solani E. and M. (abst.), 59; Infection experiments on tomatoes with Phytophthora terrestria Sherb. and a hot water treatment of the fruit, 101–105; A Macrosporium foot-rot of tomato, 415–422
RUSSELL, A. M., see ADAMS, J. F.
Rust, blister, on white pines, 513; insect transmission of, 200; peanut, 65; potato, 65; tomato, 65; wheat, 52
RUMBOLD, CAROLINE, Causes for the production of pathological xylem in the injected trunks of chestnut trees, 23–33
Rye, Rhynchosporium secalis on, 54
Rye grass, ergot, insect transmission of, 208; western smut of, 316

Saccharomyces glutinis, 538
Salix, lasiandra, Cytospora on, 443; viminalis, 390
Sambucus, glauca, Cytospora on, 443
Sapodilla, 383
Scab, potato, influence of soil temperature on, 63; wheat, 51; wheat, effect of temperature and light on, 52
Schilberszky, formation of wound tissues, 27
SCHMITZ, HENRY, Observations on some common and important diseases of the Rhododendron, 273–278; Shoe-string rot of Rhododendron and Azalea caused by Armillaria mellea, 375
Sclerotinia, cinerea, 64; fructigena, insect transmission of, 195; libertiana on tomatoes, 500
Sclerotium, on rice, 342; bifrons on aspen, 141

Seed, internal infection of, 399; selection, for control of potato mosaic, 46, for control of potato leaf roll, 407; treatment, for control of black leg of cabbage, 64, for control of bur clover leafspot, 66
Seed transmission, of cabbage black rot, 175; of Sclerotium on rice, 342
Seed potatoes, raising free from phloem-necrosis and mosaic, 48
Septoria, on tomato, control of, 60; lycopersici, 59; lycopersici, insect transmission of, 210; of wheat, vitality of spores, 51
SERRANO, FELICISIMO B., see LEE, H. ATHERTON
Sheath spot of corn, 487
Shoe-string rot of Rhododendron and Azalea caused by Armillaria mellea, 375
SMILEY, EDWINA M., The Phyllosticta blight of snapdragon, 232–248
SMITH, E. F., Chemical stimulation of cells, 29
SMITH, FLORENCE P., see ATWOOD, ALICE C.
Smut, coix, 331; insect transmission of, 200; loose, of wheat, 53; stinking, of wheat, 53
Snapdragon, Phyllosticta blight, 232; rust, 317
SNELL, WALTER H., Observations on the distance of spread of aeciospores and urediniospores of Cronartium ribicola, 358–364
Soil temperature, influence of, on cabbage yellows, 63, on Fusarium wilt of tomato, 63, on potato scab, 63
Soil treatment, chloral hydrate, 334
Solanaceae, mosaic, 35
Sorbus, scopulina, Cytospora on, 443
Sorghum head smut, 307
Sorosporium reilianum, 307
Southern Division meeting of American Phytopathological Society, 381
Soy bean, bacterial blight, 68, 119
Sphacelotheca reiliana, 328
Sphaerella rhododendri, 277
Sphaeronema fimbriata, insect transmission of, 202
Sphaeropsis, sp., 466; malorum, 453
SPENCER, E. R., Black crust of Brazil nuts (abst.), 61
Spinach blight, insect transmission of, 219
Spore discharge, mode of in Uredineae and Hymenomycetes, 315
Sporocybe azalea, 274
Sporotrichum anthophilum, insect transmission of, 196
Spraying experiments with apples, 58
Spruce, black, witches' broom, 317
STAKMAN, E. C., Recent progress in the investigation of cereal rusts, 319; and KRAKOVER, L. J., Puccinia graminis on native Berberis canadensis, 305–306
Statice rust, 317
Stem-end rot of greenhouse tomatoes, 498
Stem-girdle of tomato, 528
Stem rust of wheat, 448
STEVENS, F. L., Foot-rot of wheat and its fungous associates (abst.), 52; Changes of a decade in plant pathology (Abst.), 65
STILLINGER, C. R., Apple black rot (Sphaeropsis malorum Berk.) in Oregon, 453–458
Stink-horn fungus, insect transmission of, 207
STONE, R. E., Witches' broom of Canada balsam and the alternate hosts of the causal organism (abst.), 315; and HOWITT, J. E., Plant diseases and fungi comparatively new or rare in Ontario (abst.), 317–318
STOVER, W. G., Some results of corn root-rot work in Ohio (abst.), 55; and BEACH, F. H. and PARKS, T. H., Results of spraying the apple for blotch in Ohio in 1919 (abst.), 58
Strawberry, leaf blotch, 317; nematode disease, 66, 91
Streak disease of potato, 97
Sugar beet, bacterial leaf spot, insect transmission of, 203; curly top, insect transmission of, 216
Sugar cane, gumming disease, 429; pineapple disease, insect transmission of, 201; red rot, insect transmission of,

203; rind disease, insect transmission of, 204; root rot, insect transmission of, 207
Susceptible varieties, soy bean, to bacterial blight, 68
Sweet clover, a suspected mosaic disease of, 501
Sweet pea, anthracnose, insect transmission of, 198; mosaic, insect transmission of, 218
Sweet potato, black rot, insect transmission of, 202; ring rot, insect transmission of, 203; stem rot and tomato wilt, 306

Teliospores of Puccinia graminis, germination of, 448
Temperature, soil, relation of, to cabbage yellows, 63, to Fusarium wilt of tomato, 63, to potato scab, 63
Temperature chambers, 336
TEMPLE, C. E., Spacing tomato plants for field spraying (abst.), 59; Tomato spraying experiments for the control of Septoria (abst.), 60
Thelephora galactina, 466
THIEL, A. F., and WEISS, FREEMAN, The effect of citric acid on the germination of the teliospores of Puccinia graminis tritici, 448–452
Thielaviopsis paradoxa, insect transmission of, 197
THOMAS, C. C., Coix smut, 331–333
Thuja, occidentalis, Phomopsis on, 253; oriental is, Phomopsis on, 253
Tilletia, laevis, 53; tritici, 53
Timber decay in pulp and paper mill roofs (abst.), 314
Tip burn, potato, 61
TISDALE, W. B., The relation of soil temperature and soil moisture to the occurrence of cabbage yellows (abst.), 63; Iris leaf spot caused by Didymellina iridis, 148–163; see also JONES, L. R.; see also WALKER, J. C.
Tobacco, mosaic, insect transmission of, 218, relation of to mosaic of potato, 42
Tomato, buckeye rot, 172; early blight, 9; early blight, insect transmission of, 209; foot rot, 19; fruit rot, 19, 59; Fusarium wilt, influence of soil temperature on, 63; hot water treatment of fruit, 103; infection experiments with Phytophthora terrestria, 102; leaf spot, control of, 60; Macrosporium, on immature shipped fruit, 13; Macrosporium foot-rot, 415; mosaic, insect transmission of, 218; nail head spot, 9; Phytophthora blight of seedlings, 317; Phytophthora disease, 528; rust, 65; Sclerotinia wilt, 500; Septoria, control of, 60; Septoria, insect transmission of, 210; spacing plants for spraying, 59; stem disease, 59; stem end rot, 498; stem-girdle, 528; stem rot, 59, 317; sunburn, 59; wilt and sweet potato stem. rot, 306; tests of wilt-resistant, 59
Trametes pini, 372, 395
Transmission of disease by insects, 189
Trees, forest, Cytospora on, 442; shade, Cytospora on, 442
Trifolium, pratense L., nematode disease of, 91; repens, wilt of, 435, 441
Tropical phytopathology, 504
Tsuga canadensis, 389
Tumor, 383
Turnip, Peronospora in roots of, 321
Tylenchus dipsaci (Kühn) Bastian, 66; on red clover and strawberry, 91–95

Uredineae, shape of basidia and mode of spore discharge in, 315
Urediniospores of Cronartium ribicola, spread of, 358
Urocystis cepulae, 323
Uromyces limonii, 317
Urophlyctis alfalfae, 65
Ustilago, coicis, 331; tritici, 53; zeae, 307

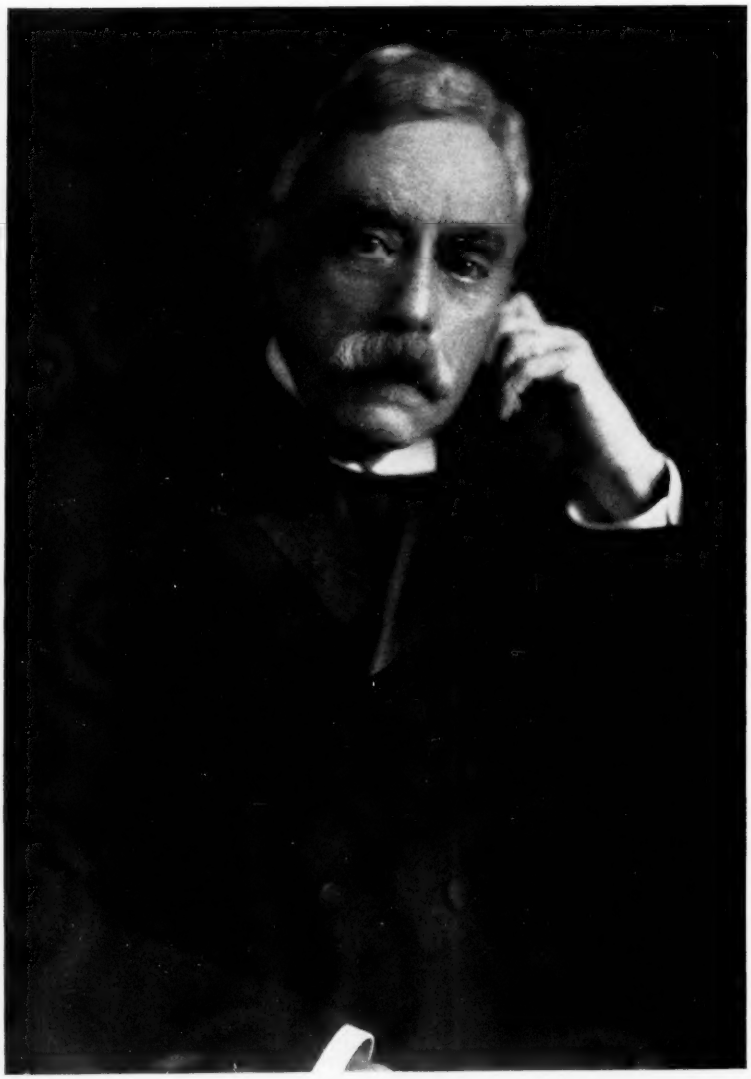
Vanilla, diseases in Tahiti and Moorea, 341
Vascular system of plants, effect of chemicals on, 29
Velvet bean, bacterial leaf spot, 73
Venturia inaequalis, 58
Vetch, formation of wound tissue in, by injection of chemicals, 30, by mechanical injury, 27
Verticillium alboatrum, 317

WADE, A. E., see HUNGERFORD, CHAS. W.
WALKER, J. C., Occurrence and control of black leg of cabbage (abst.), 64; Experiments upon formaldehyde-drip control of onion smut, 323–327; and TISDALE, W. B., Observations on seed transmission of the cabbage black rot organism, 175–177; see also JONES, L. R.
Walnut blight, insect transmission of, 200
Washington meeting of the Advisory Board of American Plant Pathologists, 257–258
WEIMER, J. L., The distribution of buckeye rot of tomatoes, 172; see also HARTER, L. L.
WEIR, JAMES R., Note on the pathological effects of blazing trees, 371–373
WEISS, FREEMAN, see THIEL, A. F.
Wheat, bunt infection and soil moisture, 53; foot-rot, 52; Kanred, resistant to leaf rust, stem rust, stinking smut, and stripe rust, 52; loose smut, 53; scab, effect of temperature and light on, 52; Septoria, 51; stinking smut, 53; rust, insect transmission of, 200; varieties resistant to leaf rust, 164
White clover, wilt, 435
White leaf of Rhododendron, 275
White pine, blister rust, control in 1919, 177; blister rust, insect transmission of, 209; needle blight, (abst.), 315
Willow, see Salix
WILSON, J. K., Device for growing large plants in sterile media, 425–429
Wilt, of banana, 504; bacterial, of solanaceous plants, insect transmission of, 195; Sclerotinia, of greenhouse tomatoes, 500; of white clover, 435
Witches broom, of Canada balsam, (abst.), 315; on Rhododendron, 275
WOLF, F. A., Bacterial blight of soybean, 119–132; A bacterial leaf spot of velvet bean, 73–80
Wood-destroying fungi, 61
WOODWORTH, C. M., and BROWN, FLORENCE COERPER, Studies on varietal resistance and susceptibility to bacterial blight of soy bean (abst.), 68
WORTLEY, E. J., see MURPHY, PAUL A.
Wound tissues, produced by injection of chemicals, 23; produced by mechanical injury, 25, 27

Xylaria polymorpha, 466
Xylem, pathological, produced in chestnut by injection, 23; in wounded vetch seedlings, 28

Yellows, cabbage, influence of soil temperature on, 63
YORK, H. H., Late seasonal production of aecia of Cronartium ribicola, 111

ZUNDEL, GEORGE L., see DANA, B. F.



WILLIAM GILSON FARLOW

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WILLIAM GILSON FARLOW

G. P. CLINTON

WITH PORTRAIT, PLATE I

Professor William Gilson Farlow was born in the vicinity of Boston, Mass., on December 17, 1844. He died in Cambridge, Mass., on June 3, 1919, in his seventy-fifth year. His death occurred after a comparatively short illness, at his residence of recent years on Quincy Street opposite the main yard of Harvard University, his beloved Alma Mater. Although retired from active teaching for many years, Professor Farlow continued to the last in his work at the Cryptogamic Herbarium which he founded, supported financially during his life, and to which on his death he gave his library, botanical specimens, and an endowment fund.

Many things contributed to make Professor Farlow very successful in his life work—family, wealth, training, social prestige, position, native ability, and systematic and continued effort, all had their influence. He greatly loved his work, otherwise he would have taken things easier during his declining years. He was very fortunate in the teachers under whom he studied, for in their time there were none at least to exceed Gray and deBary. His ability was evident to anyone who came in personal contact with him. To the mind of the writer these three factors, love of his work, sound training, and native ability, were chiefly responsible in making him the foremost cryptogamic botanist of America. Furthermore, at the time of his death he was generally considered by his fellow botanists as Dean of the active American botanists, as indicated by length of service, honors, etc.

Professor Farlow graduated from Harvard College in 1866 and from the medical department of the University in 1870. His interest in botany induced Doctor Gray to make him his assistant in cryptogamic botany. After two years of teaching, young Farlow decided that he needed more training in this subject, and such not being available in America, as he was a pioneer teacher here himself, he went to Europe, studying in Ger-

many and France. While under deBary at Strassburg he came in contact not only with this great teacher and investigator, but also with a number of his students from different parts of Europe, who, in after years, became leaders in various lines of botanical work. This experience no doubt greatly influenced his own later development.

Stimulated by his European training of two years, he came back to Harvard and was made Assistant Professor of Botany, and stationed at the Bussey Institution at Jamaica Plains. It was here that he began a series of articles on plant diseases that eventually included investigations of the potato rot, black knot, downy mildew of grape, smut of onion and the relationships of Roestelia and Gymnosporangium, the first paper appearing in 1875. No matter how closely Harvard cryptogamic botanists in later years have clung to the pure side of this science, one cannot get around the fact that at the start the applied side was ably handled by Farlow, and that his earliest students also published similar articles. As this was at a time when our state institutions, with only one or two exceptions, had not manifested any particular interest along this line, we can justly claim that Farlow, with Burrill, was really the pioneer plant pathologist of America, although he may be antedated by others as mycologists.

Not only was Farlow doing investigational work at this time, but he was actively engaged in teaching at Bussey and also at Cambridge in both the regular and summer school courses. His first advanced student was Byron D. Halsted, a recent graduate of Michigan Agricultural College, and the first to obtain a doctor's degree under him. Since then many American botanists have had the privilege of receiving part of their botanical training under his immediate direction or in the department he created and still served in an advisory way till his death.

In 1879, the funds of Bussey becoming diminished, Farlow was transferred to Harvard University proper and made Professor of Cryptogamic Botany. Here he continued under the varying changes of the University and the times, building up the teaching department, creating the Cryptogamic Herbarium, training scientific men who might give their undivided time to the subject, either as teachers or investigators or as both, publishing botanical articles of merit, and advancing the interests of cryptogamic botany throughout the country as has no other man. Remembering that he started in at a time when there were few men in the country interested in this branch of botany, that there was no teacher who gave it much attention in his classes, that laboratory work or equipment for such was not to be had, and that he lived to see the day when it really predominates the science of botany in the United States and when many men make it their life work and get their living out of it (I say "living" not necessarily meaning anything more), is it any wonder that he was interested in his

work or that botanists generally honor him for the great part he had in its development?

And honors did come to Farlow from his own and other universities of this country and Europe, not only through honorary degrees but in other ways as well. The various prominent scientific societies of the world had him enrolled as a member and he became president, at one time or another, of most of those in America. Of honors obtained we need mention only a few—Member of the National Academy of Science, London Linnaean Society, British Association for the Advancement of Science; President of the A. A. A. S., Botanical Society of America, American Naturalists; honorary degrees from Harvard University, University of Wisconsin, University of Glasgow, University of Upsala.

In middle life Professor Farlow was married to Lillian Horsford, who still survives him. To visiting botanists whom Farlow aided in their examination of specimens at the Herbarium, there was usually added the pleasure of entertainment at his home and an inspection of his botanical library which was kept there. In this way Mrs. Farlow came to know many of his fellow-workers, and the charm of her personality was appreciated by all.

We have so far recorded in a general way a few of the main facts in the life of Doctor Farlow. The time given for the preparation of this article has been too short to allow us to present facts or incidents that are not already at hand. Neither do we wish to make this paper too much in the nature of a formal biography but rather as the loving remembrance of one who, through twenty-five years of correspondence and two years of student life, feels that he owes a debt of gratitude, for favors received and inspirations aroused, to a master of high order. It seems fitting, therefore, that we write further concerning Doctor Farlow as a man and as a scientist, and of his service to the science of botany.

If in speaking of him as a man the writer touches on intimate things no offense is intended, and his excuse is that we usually respect men as much for what they are in their natural selves as for the names they have attained. Farlow was quite short in stature, though well proportioned. When we first met him his hair was turning grey, but his cropped mustache and shaggy eye-brows, with a considerable tinge of red, suggested that in his youth he might have been classed as red-headed. He had a decided roll, or side glance, of his eyes in talking, and what might possibly be termed a Boston or English inflection in his speech, which was rather rapid, so that one had to keep his ears and mind alert to catch all he said. The writer can see him now as he looked each morning after his arrival at the Herbarium making his daily pilgrimage to the shrine of Thaxter, passing rapidly through the advanced laboratory, taking in at

a glance the students there, perhaps recognizing some one with a nod, and disappearing into the chamber of consecrated and concentrated work, thence to emerge shortly afterward with Thaxter escorting him back to his room—the short and the tall—earnestly engaged in some discussion, each mutually dependent on and helpful to the other! Such earnest comradeship devoid of the ordinary frivolities of men was charming to behold.

We must admit that dignity was quite an attribute of Farlow. Those who have seen him writing his letters, as he sometimes did, standing at his desk, did not take this to be unusual for it caused him no inconvenience, such as most of us would have had. That he knew how to put people in their proper places is illustrated by the remark that a "character," who was claiming newspaper fame through his discovery of fungous fairy rings, let out in the laboratory one day: "He may be small but one may not presume to impose on him on that account, except to his sorrow." His dignified attitude is further shown by the following story he told on himself: It seems that a western botanist was calling on him at an inconvenient time and during very warm weather. On their way to the Gray Herbarium, to which Farlow was taking him, this botanist as they passed through Cambridge Common took off his coat and lay down on the grass, and suggested that Farlow follow suit. It was the informality of the west meeting the formality of the east, and neither could understand the other. For, as Farlow later said, "What would people think of me if they saw me doing this." When one is in Cambridge one must do as the Cambridge professors do, is the answer.

Still, with all his reserve, Farlow was witty and saw the humorous side of things. He was apt to use this wit in a refined and semi-hidden manner by way of suggestion to a person with whom he might be talking, so that one was not always sure just when he came in for his share of mild criticism. Among the Harvard professors, the writer was once told, Farlow shared honors with another member of the faculty as being the wittiest man there. Those who heard him give, or have read, any of his general addresses, will appreciate this fact. Especially interesting to all present was the presidential address he gave at the botanists' dinner at Cleveland in 1912.

He was somewhat critical in his judgment of men and their work. Perhaps this was partially responsible for the feeling that has gone out that Harvard does not wish great numbers of advanced students so much as a few of unusual promise. He did not judge others or their work, however, with undue harshness but rather his extended experience in reviewing literature—for he went over, at least in a general way, all of the current botanical articles—gave him the ability to pick out the weak points with little effort. In discussing this or that botanist with him, if one did not

know this, he might misjudge Farlow's real estimate of the man under discussion.

His letters also sometimes show this critical attitude, in fact, even when writing of one of whom he thought highly. The following extract from an old letter (the italics being used for camouflage) illustrates the point under discussion: "*Smith* was in Cambridge for a few days. I am sorry that he did not make a very favorable impression. He looked over the covers of *two genera of fungi* but made no microscopic examination and seemed content to make a copy of hosts and localities without making any critical study of the specimens. He did not look at any of the exsiccati and seemed displeased that he could not have all the specimens of the two genera laid out before him at once. Evidently he had no idea of what was in large sets of exsiccati and I could not, to save my life, make out what he wanted and could only infer that he did not know what he wanted himself. He made me a present of about half a dozen specimens. I wonder whether he thought I did not have plenty of our common species," etc. And this was a botanist who had made a name of some prominence, but you cannot guess who he was from this tale.

Professor Farlow liked to hear of the current gossip about botanists and botanical things, and if this did not come through ordinary conversational channels, he occasionally went after it by direct inquiry. In this way he kept in touch with men whom he had not met or seen for some time, and with events with which he had no very direct connection. Chestnut Blight and White Pine Blister Rust investigations were two things that thus solicited his interest, and the writer would like to print some of his spicy comments just to show how interested he became in subjects that mix politics, advertising and investigational work more or less together.

We have dwelt thus at length on this personal side of his life to show that he was a human as well as a dignified Harvard professor, and that he had a personality that one always likes to find in a great man, to give him color as it were. So whenever his former students got together he was always brought up for discussion, and his ears, figuratively speaking, must have often tingled from the personal comments that followed, showing in what high regard he was held by all.

As a scientist we must judge him by the articles he published, and here the writer ventures a criticism of a man who was himself a critic. He published *too little* for what ke knew and for what he had done. This is not a criticism that can be made of many botanists, however. It was voiced in his presence once by a professor who did not mean at all to be sarcastic, when he said: "In one of your recent publications, Doctor Farlow, published some ten years ago," etc. The writer believes that every American botanist regrets that Doctor Farlow did not leave on record in

published papers more of his vast knowledge of lichens, mosses, algae, and fungi, knowledge that was so extensive and exact that an authority on any of these groups was bound to pay profound respect to his opinions concerning the same. We have, or have had, botanists who surpassed him in knowledge concerning each of these groups, save the fungi, but none who equalled him in familiarity with them all. He was truly entitled Professor of Cryptogamic Botany. Just as surely as the old time Professor of Natural History has passed out of existence, so to the mind of the writer, he represents the last of those who were able satisfactorily to cover the wide field of cryptogamic botany.

Aside from his New England Algae and a few similar papers, he published little concerning the chlorophyll-bearing cryptogams. However, if he did not publish along these lines, he helped and stimulated others to do so. His papers on the fungi were more numerous and all of high grade. They were true contributions to our knowledge of the same whether made in the form of short notes on personal collections or more extended morphological and systematic articles. They covered a wide range of subjects for he considered all genera as worth knowing. The writer has always thought, however, that he was more interested in the rusts than in other groups.

No doubt his greatest contributions, at least in size and general value, were those concerning the bibliography of fungi. Starting in 1887 he issued, with Trelease, a very complete bibliography of all articles on American fungi published before that year, and this was followed the next year by a supplementary list, by Farlow alone, of addenda and those articles published in 1887. Critical notes add greatly to the value of this work. In 1888, with Seymour, he published the Host Index to Fungi in the United States. This work has been of even greater value to botanists, especially as an aid to identification of species. It should be brought up to date by Thaxter and Seymour as a memorial volume to Farlow. His most pretentious work, however, is the Bibliographical Index of North American Fungi, the first part of the first volume being issued through the Carnegie Institution in 1905. The immensity of this work is shown by the fact that the genera treated, arranged alphabetically, include only those from Abrothallus to Badhamia. It is the earnest hope of all botanists that this valuable work may be continued and that provision has been made for the early appearance of subsequent parts.

Finally, what was Farlow's influence on the science of botany in general, and cryptogamic botany in particular in the United States? This has already been indicated in a general way. We wish to indicate it in a little more precise form under the following headings:

1. He was a pioneer investigator in plant pathology and so helped this branch to obtain needed recognition in the botanical world at a time when botanists were given too largely to the consideration of the morphology and systematic classification of flowering plants. In his investigations along the lines of pure science he set a high standard for accuracy of statement and originality of information. In his bibliographical compilations of the literature of fungi he has given aid of great value to all other investigators.

2. In the Harvard Cryptogamic Laboratories and Herbarium he started an institution new of its kind in this country and for many years leading in facilities for under-graduate and post-graduate work all similar institutions that followed. The high ideals of fundamental and thorough instruction there put in practice have been ably carried out by his successors and assistants.

3. He turned out as students from these laboratories many of the leading American botanists. Through his wonderful library and the herbarium he aided visiting botanists from time to time to obtain information and see specimens not generally available. He brought together in the herbarium one of the most complete collections of exsiccati of fungi that exists today in the world. Through his own collections, specimens sent him, and the purchase or donation of such valuable collections as those of Curtis' fungi, Tuckerman's lichens, Sullivant's and James' hepatics and mosses, and algae by many noted collectors, he has made this herbarium a mecca for botanists interested in many lines of work.

4. Through his attendance at botanical conferences in this country and Europe, and through published opinions on the question of botanical nomenclature, he has exerted a strong influence in the form of a sane and stable use of scientific names as applied to fungi. Through this conservative treatment, as compared with the more radical views held by some in this country, he has maintained a connecting link with European botanical views on this subject, which we hope some day may lead to uniformity of usage everywhere.

5. Finally, through correspondence with botanists all over the country, aiding them by looking up references in unusual publications, sending specimens from his herbarium for their benefit, or determining specimens sent him, he has given great aid in furthering the investigations of others. This is a sort of work that often goes unappreciated by botanists, and perhaps explains in a measure why he did not publish more himself, as he gave much of his time to others. We have before us a hundred or more letters, all in his hand writing, many of them giving information asked for and requiring effort and care on his part to obtain. If to these are added the hundreds of letters he has written to others in the same helpful way, we gain a truer insight into his influence on botanists and their work.

The writer had the privilege last March, shortly before Doctor Farlow's final illness, of spending part of the day at the herbarium and in his library obtaining desired information covering certain smuts. As always, there was the same chatty talk concerning botanists, a little warning not to stir up a mutual friend too much about the war, the furnishing of desired specimens, and the repeated bringing of reference books opened at the designated page. It is a pleasure thus to think of him still at work in his beloved herbarium and library, doing favors for others.

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STUDIES WITH MACROSPORIUM FROM TOMATOES

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WITH PLATES II AND III AND ONE FIGURE IN THE TEXT

The early blight or "nail head" spot (*Macrosporium sp.*) on tomato fruit has been known to growers and investigated by pathologists for a number of years. It is still a question, however, whether:

(1) Infection in the field can take place without previous injury to the fruit,

(2) The disease can originate and spread in transit on winter-grown tomatoes in the South,

(3) The same or different species of Macrosporium cause similar or different lesions in the various tomato growing sections,

(4) Macrosporium on tomatoes is identical with *M. solani* as found on the potato.

The work here reported was done during the past three years with winter-grown tomatoes in southern Florida. Additional observations were made near Washington and in some New Jersey fields. Diseased specimens for study and isolations were also collected or received from Texas, Louisiana, Tennessee, and Maryland.

The great destructiveness of this disease in the field has been recorded by Edgerton and Moreland (1), Sherbakoff (2), and more recently by Hesler (3).

Edgerton and Moreland (1) say: "It probably stands as a close second to the wilt in destructiveness, and in many regions it is the all important disease. . . . . At Norwood, where there were over 200 acres in tomatoes, the loss due to this disease was estimated to be at least 50 per cent."

Sherbakoff (2) states: "An accurate estimate of the damage caused by it is not available, but it is safe to say that wherever the disease is present a loss up to one-half the crop is sustained, even during a comparatively dry season. A much heavier loss is not rare." Hesler (3) states: "Growers and others agree that a least 20 per cent of the fruits are culled out at the packing house on account of blight lesions. In addition to this loss, many tomatoes are not picked on account of early blight spots." The observations made by the writer lead him to conclude that in southern Florida where, according to the Crop Estimates Report (9) 12,925 acres are grown,

this disease is by far the most destructive and widespread with which the growers have to contend. In a letter received from one of the growers, referring to this disease the following statement is made: "I have lost in the past eight years 20,000 crates."

Differences between old and new spots. The difference in appearance between an old spot and one resulting from a relatively new infection has enabled the writer to make numerous counts in the field with a view to determining whether the size and age of a fruit have any relation to infection.

The young spots are superficial, light brown in color, with an indistinct margin. With age the lesions become more and more distinct, the color gradually changing from light brown to dark brown or gray, with the margin becoming more definite. The majority of the spots after they have attained the size of a nail head have reached the maximum size. They remain in this condition unless other fungi gain an entrance. With age the spot shows a break or crack. It is this opening which affords entrance for other fungi and causes the lesion to enlarge.

There is a period of four to eight weeks from the time the spot is first visible to the time when it takes on the appearance of an old spot, that is, becomes dark brown in color, sunken, and possibly shows a distinct break in the skin.

Time of infection in the field. With the above knowledge as to the differences in appearance of an old and new spot, counts were made from a number of badly infected fields. In all cases the circumference[1] of the fruit was measured and the appearance of new spots noted. After making some preliminary measurements and counts it was decided to divide the fruits into those six inches or less in circumference and those more than six inches in circumference.

In table 1 are given the counts made from a badly infected field, part of which was sprayed with Bordeaux after the first picking of fruit had been made. All the fruit from the size of a marble to mature fruit was picked. It shows therefore, not only the new infections on the small and large fruits, but incidentally also the effect of spraying on the severity of the infection, the percentage of disease in the sprayed part being 51.4 as compared to 79.6 per cent in the unsprayed. The increase in the quantity of diseased fruit from December 22, when the first count was made, to January 5, when the second count was made, was almost 54 per cent. On December 22, 1917, 174 tomatoes were picked from another field where the

[1] Circumference of the fruit referred to throughout the paper refers to the polar circumference, i.e., in taking the measurement the tape passed around the stem and blossom end of the fruit.

TABLE 1

Development of Macrosporium on large and small fruit and effect of one spraying

DATE PICKED	NUMBER OF PLANTS	TREATMENT	NUMBER OF CLEAN FRUIT		NUMBER OF FRUIT WITH OLD SPOTS		NUMBER OF FRUIT WITH NEW SPOTS		PER CENT DISEASE NOT SPRAYED	PER CENT DISEASE SPRAYED
			Circumference more than 6 inches	Circumference less than 6 inches	Circumference more than 6 inches	Circumference less than 6 inches	Circumference more than 6 inches	Circumference less than 6 inches		
December 22	30	Unsprayed	107	76	0	0	6	58	25.9	
January 5	30	Unsprayed	39	12	20	0	0	179	79.6	
January 5	15	Sprayed	40	80	14	0	0	113		51.4
Total	75		186	168	34	0	6	350		52.4

disease was present. All the fruit from the size of a marble and up was picked and immediately sorted as follows:

More than 6 inches in circumference, healthy 67
More than 6 inches in circumference, showing new infection 0
Less than 6 inches in circumference, healthy 54
Less than 6 inches in circumference, showing new infection 42
Less than 6 inches in circumference, showing older infection 11
Per cent of new infection in large fruit 0
Per cent of new infection in small fruit 39.2

To determine whether new infections would show up on the fruit after being held, an equal number of clean, small and large fruits was picked December 22, and kept at the laboratory for seven days. At the end of that time counts were made with the following results:

Fruits more than 6 inches in circumference remained healthy 77
The fruit less than 6 inches in circumference showed:
  Fruits with one new infection 13
  Fruits with two new infections 7
  Fruits with numerous new infections 41
  Fruits remaining healthy 16
Per cent of fruit more than 6 inches in circumference developing new spots 0
Per cent of fruit less than 6 inches in circumference developing new spots 79.2

A repetition of the above counts was made April 12. In this case three baskets of immature fruit varying from 1 to 6 inches in circumference were picked and carefully examined for early blight spots. Those show-

ing any suspicious or definite lesions had these marked by ringing with india ink and were in this way excluded from the final counts. The fruit was examined April 17 and April 22 for the development of new spots. The results are shown in table 2.

Seventy-five fruits more than 6 inches in circumference picked at the same time and kept under identical conditions remained healthy.

For comparison the salient points in the above counts have been brought together and summarized in table 3. The figures show conclusively that

TABLE 2

Development of Macrosporium on immature fruit

NUMBER OF NEW SPOTS DEVELOPED	NUMBER OF FRUIT IN BASKET 1		NUMBER OF FRUIT IN BASKET 2		NUMBER OF FRUIT IN BASKET 3		TOTAL FRUIT	
	April 17	April 22	April 17	April 22	April 17	April 22	April 17	April 22
1 spot	10	12	4	5	19	9	33	26
2 spots	13	9	12	4	9	9	34	22
3 spots	8	5	3	3	4	8	15	16
More than 3 spots	34	45	46	60	38	49	118	54
Remaining clean	9	3	11	4	9	4	29	11

TABLE 3

Development of Macrosporium on mature and immature fruit

COUNT NUMBER	MATURE FRUIT			IMMATURE FRUIT		
	Number healthy	Number showing new infection	Per cent diseased	Number healthy	Number showing new infection	Per cent diseased
I	186	6	31	168	350	67.5
II	67	0	0	54	42	39.2
III	77	0	0	16	61	79.2
IV	68	0	0	11	218	95.1

new infections in the field very seldom occur on mature fruit or fruit more than 6 inches in circumference.

Shipment of fruit.[2] Some growers have been of the opinion that the early blight spot can originate in transit. In every case, however, where a shipment of infected fruit was traced to the point of origin it was found that the fruit was spotted at the time of packing. Rands (4) found the disease in the Chicago and Madison markets on tomato fruit from the South.

[2] Assistance in the examination of the fruit at the point of arrival was given by Mr. G. H. Godfrey, Dr. N. E. Stevens, Dr. V. B. Stewart, Dr. Geo. K. K. Link, Mr. Pomeroy and Mr. Van Orman.

He says, "The evidence here indicated that the disease had developed during transit."

Throughout the winter season, December to May, 1917, crate shipments of tomatoes were made to Washington and New York City. Nail head spots on fruit from badly infected fields as well as from clean fields, were marked by ringing with India ink before packing.

A total of 17 express and freight shipments were made, involving 75 crates. The results of these shipments showed that mature fruit picked green, as is usually done, and healthy at the time of packing, showed no new spots on their arrival. Moreover, fruit badly spotted at the time of packing and packed in such a way that diseased and healthy fruit alternated showed no spread of the disease. This was done both with tomatoes wrapped and unwrapped.

TABLE 4

Development of Macrosporium on mature and immature fruit in transit

NUMBER OF NEW SPOTS	IMMATURE FRUIT			MATURE FRUIT			PER CENT DISEASED	
	Basket 1	Basket 2	Total	Basket 3	Basket 4	Total	Immature	Mature
0	14	4	18	24	23	47		
1	14	8	22	0	1	1		
2	13	6	19	0	0	0		
3	19	5	24	0	0	0		
4	5	3	8	0	0	0		
5 or more	26	33	59	0	0	0		
Total.....	77	55	132	0	1	1	88	2

On the other hand, all shipments of immature fruit, that is, fruit less than 6 inches in circumference, picked green and clean from an infected field, developed numerous spots at the time or soon after their arrival.

In table 4 the counts are given from one of the shipments. The shipment was made April 14 from Miami, Florida, in a car containing over 400 crates of tomatoes, and was examined at New York City ten days later. Repetition of this work gave similar results and confirmed the evidence of counts made in the field, that mature fruit as indicated by the size never becomes infected.

Artificial infections. The very excessive spotting of fruit in badly infected fields and careful examination of such fruit would seem to indicate that natural infection in the field takes place without previous injury to the tomato. Nevertheless, the writer heretofore had not been able to produce infection without injury to the fruit. This has been the experience of previous investigators as shown by the statements of Rands (4),

McCubbin (5) and Jones and Grout (6), all of whom were unable to produce typical symptoms on the fruit without previous injury. In view of the observations made in the field that infection takes place on the very young fruit, the idea suggested itself that artificial infection without previous injury could be obtained by inoculating young or immature fruit.

Clean fruits of various sizes were collected and placed in moist chambers and sprayed with a decoction of spores obtained from pure cultures according to the method described by Kunkel (7) and Rands (8). At the end of six days they were removed from the moist chambers, wrapped in paper, and kept at room temperature. They were examined again at the end of eight days at which time the following notes were made:

NUMBER OF FRUIT	CIRCUMFERENCE OF FRUIT	NUMBER OF SPOTS ON EACH FRUIT
	inches	
12	6 or more	0
1	1	1
1	1	2
5	1	6
3	2	0
4	2	3
2	3	0
5	3	6 or more
1	4	0
2	4	1

Artificial inoculations, in the laboratory as well as in the field, on uninjured fruit have been repeated a large number of times with results similar to those presented above. Positive infection is obtained when the inoculation is made on young, immature fruit approximately less than 6 inches in circumference. A period of from eight to ten days elapses from the time the inoculation is made to the time when the symptoms are first visible.

The results of the artificial infections in the laboratory and field furnish additional indirect proof that the disease cannot originate or spread in transit on mature green fruit of the size which is generally shipped.

Types of lesions found on fruit and stems, and identity of fungi isolated. The lesions of early blight on tomato fruit as found in Florida and other Gulf States are small, circular or irregular, brown to gray spots, seldom attaining a size greater than that of an ordinary nail-head, as shown in plate II. Occasionally a much larger spot is produced, but similar in color to the above as shown in plate III, figure A. This has been referred to during the progress of this work as a spreading Macrosporium spot. In Florida this last

type of lesion is less common. In addition to these two types of lesions, tomato fruit collected in New Jersey have shown still a different spot (plate III, fig. B). It was found occurring as one or two brown spots on each fruit, much larger than the nail-head spot. In addition to the numerous isolations made from these fruit spots, isolations were made from the stems and leaves of southern-grown tomatoes as well as from those grown in the north.

It was of interest to determine whether all of the lesions on the fruit, in the same or different regions, are caused by the same Macrosporium, and, moreover, whether the fruit spots are caused by the same species which produces disease on the stems and leaves.

The question whether the Macrosporium causing a disease of tomatoes is the same as the one causing the early blight of potatoes is also of interest. Thus, Rands (4) considers the two identical. He says: "Early blight in Wisconsin occurs commonly on potato, tomato, and eggplant. The identity of the fungus on these hosts has been established by morphological and cultural studies and by reciprocal cross-inoculations from single spore cultures."

Kunkel (7), on the other hand, more recently considers them different. He says, "They should be considered separate species, rather than strains of a single species." He refers to the Macrosporium from tomatoes as *M. tomato* Cooke and considers it distinct from *M. solani* E. & M from potatoes.

While a large number of isolations were made from tomatoes and potatoes and the cultures obtained studied, it will suffice for the purpose of illustrating the points brought out in the discussion to refer only to the following Macrosporium cultures:

17–19. Isolated from "nail-head" spots on green tomato fruit from Florida, in 1917.

17–57. Isolated from damping-off potato seedlings from Maine, in 1917.

18–110. Isolated from "spreading" spots on green fruit from Florida, in 1918.

19–130. Isolated from large brown spots on green fruit from New Jersey, in 1919.

19–134. Isolated from typical early blight spots on potato leaves from Maine, in 1919.

19–147. Mounts were made direct from infected fruit, showing typical "nail-head" spots on green tomatoes from Florida, in 1919.

19–148. Isolated from ripe tomatoes; not parasitic, but occasionally found as a saprophyte on tomatoes. From Florida, in 1919.

19–154. Isolated from "nail-head" spots on green fruit from Florida, in 1919.

19–173. Isolated from diseased tomato stems, causing a "foot-rot" or canker in the field and seed-bed. From Delaware, in 1919.

Studies were made with these cultures, as regards their growth on various media, ability to produce infection, and measurement and shape of their spore forms. The results of these studies are here summarized.

Growth on various media. Cultures marked 17–19, 18–110, 19–154, 19–170 are identical, producing a copious, grayish-white to green growth on potato, bean, and other agar media. The cultures marked 17–57, 19–130, 19–134, and 19–173 produce a much darker growth, accompanied by a light, wine-colored to deep red or claret discoloration of the media. As a result of their growth on media, the cultures isolated can be separated into two distinct groups.

Inoculations. The cultures marked 17–19, 18–110, 19–154, and 19–170 were all able to produce typical "nail-head" spots on the fruit, stems, and leaves as shown in plate II. The inoculations on the fruit, when made without injury, were successful only when young immature fruit was used.

Typical "nail-head" spots on young fruit were not obtained with the other cultures isolated. Cultures marked 17–57, 19–130, 19–134, and 19–173 were each able, however, to produce large brown spots on green tomato fruit, provided the fruit was injured previous to inoculations, as shown in plate III, figure B. The rot produced was similar in appearance to the original lesion from which 19–130 was obtained.

On the stems and roots 19–173[3] was especially virulent, causing a "foot-rot" at the base and a rot and girdling of the stem at any point where the mycelium of the fungus was inserted. Cultures 17–57, 19–130, and 19–134 were likewise able to produce similar lesions on the stems, but were certainly less virulent in this respect than 19–173. Cultures 17–19, 18–110, 19–154, and 19–170 were unable to produce such stem lesions.

Thus, typical "nail-head" spots on uninjured green fruit are seldom, if ever, obtained from artificial inoculation with *Macrosporium solani* from potatoes, or with Macrosporium from tomatoes which resembles it in culture. On the tomato leaves, however, *M. solani* is able to produce a spot indistinguishable from that produced by the "nail-head" Macrosporium. The results of these inoculations, therefore, likewise separate the Macrosporium cultures into the same two distinct groups.

Spore measurements. The cultures were grown on potato agar, and spores for measurements were obtained by the method previously referred to. All of the measurements were made from spores of relatively the same age. A total of one hundred spore measurements was made. The spores for these measurements were obtained at four different times,

[3] A more detailed discussion regarding a disease which this fungus causes will be considered in a separate paper.

approximately twenty-five spores being measured at each time. Great variation was found among the individual spores for the same culture. It was also a problem whether the entire length of the spore, including the elongated pedicle or beak, should be measured. It was found that greater variation occurred in this beak than in the body of the spore. In table 5, however, which summarizes the results of these measurements, both are included. The position in the spore where the body ends and the beak begins was necessarily more or less arbitrary; nevertheless, the following points were considered in deciding this question: (a) the light brown tinge of the body, as compared to the hyaline beak, (b) the more uniform diameter of the beak, and (c) the greater distances between the cross septa in the beak as compared to those in the spore body. Examination of the table of measurements (table 5) and comparison of the figures in figure 1 show that the Macrosporiums isolated from typical "nail head" spots vary considerably in size. In addition, there is shown still greater variation in the spores from the isolations from the different lesions. Thus, 18–110 has a length of the spore body, not including the beak, of 47.3 microns, as compared to 79.0 microns for the Macrosporium isolated from New Jersey tomato fruit. Between these two extremes various gradations in size of parasitic Macrosporiums are shown.

Notwithstanding these variations, it is nevertheless evident that the spore measurements likewise separate the Macrosporiums into the same two groups as found when these were studied in culture, or as regards the kind of lesions produced. Those Macrosporiums isolated from typical "nail head" spots from fruit, stems and leaves are invariably smaller in size than *Macrosporium solani* from the potato, or the cultures 19–130 and 19–173, which resemble it.

In addition to the difference in size found in these two groups, the following differences are found, as shown in figure 1. *Macrosporium solani* 19–130 and 19–173, show a large proportion of the beaks forked. In the remainder of the cultures, while a forked beak may occasionally be present, this is an exception rather than the rule. This characteristic of *M. solani* is especially well illustrated by Rands (4) in his figure 4. In addition, the beaks of the spores of *M. solani* from potatoes and Macrosporium cultures from tomatoes resembling it, such as 19–130 and 19–173, are generally coarser, i.e., of larger diameter than those of the Macrosporiums isolated from typical "nail head" spots.

The cultures resulting from isolations made from tomato fruit from Tennessee, Texas, and Louisiana resemble in all respects the cultures obtained from typical "nail head" spots from Florida fruit, which are discussed here.

TABLE 5.

Measurements of Macrosporium

FUNGUS	SOURCE	LENGTH IN MICRONS						WIDTH IN MICRONS			SEPTA		
		Spore body			Spore body plus beak								
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
17–19	Nail-head spot. Tomato fruit. Florida	37.8	77.7	56.0	100.8	218.4	164.4	12.6	21.0	17.8	6	10	7
17–57	Potato seedlings. Damping off. Maine	39.9	123.9	74.3	65.0	256.2	157.4	12.6	23.1	17.4	4	14	7
18–110	Large spreading nail-head spot. Florida	29.4	69.3	47.3	54.6	279.3	132.6	10.5	23.1	16.9	4	9	6
19–130	Large spot. Ripe tomato. New Jersey	42.0	128.2	79.0	88.2	407.6	288.5	10.5	25.2	20.1	5	13	8
19–134	Early blight spots. Potato leaves. Maine	29.4	111.3	67.0	71.4	247.8	153.1	8.4	23.1	18.2	4	12	7
19–147	Nail-head spots. Green tomato. Direct Mounts. Florida	31.5	71.4	47.6	69.3	163.8	114.2	10.5	18.9	14.4	5	9	6
19–148	Saprophytic Macrosporium. Green tomato. Florida	21.0	42.0	31.5	31.5	75.6	52.6	8.4	18.9	12.7	4	7	4
19–154	Nail-head spot. Tomato fruit. Florida	35.7	88.2	58.7	75.6	323.4	189.3	12.6	31.5	20.7	5	11	7
19–170	Nail-head spot. Tomato fruit. Florida	29.4	81.9	56.7	65.1	201.6	126.9	10.5	21.0	16.5	5	12	7
19–173	Cankers on tomato stems. "Foot Rot." Delaware	56.7	98.7	75.1	157.5	350.7	244.1	14.7	23.1	18.0	5	10	8
M. solani	Measurements by Saccardo				100.0	140.0		15.0	18.0				
M. tomato	Measurements by Saccardo				100.0	120.0		20.0	22.0				

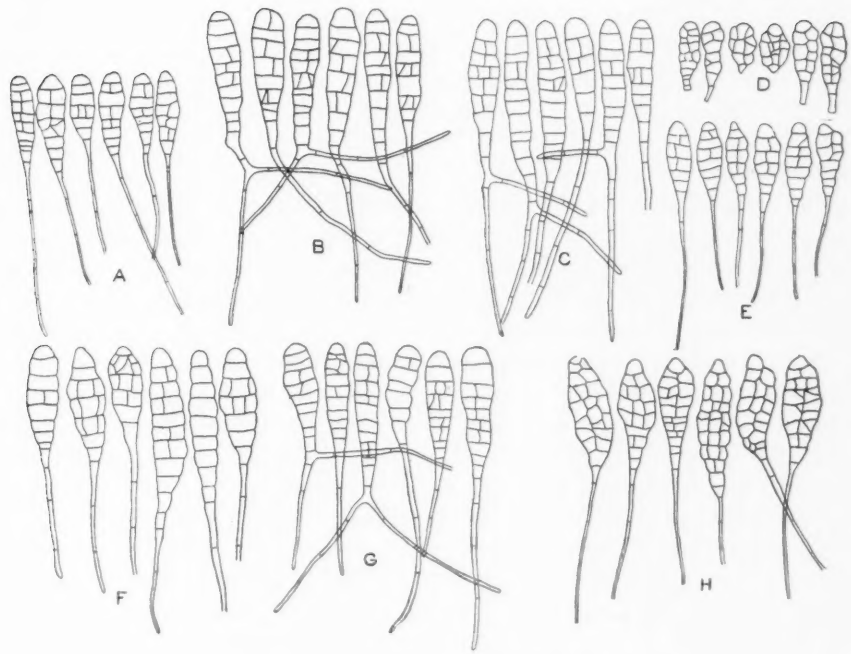

FIG. 1. SPORES OF MACROSPORIUM

A. *M. tomato.* From culture marked 17–19. Isolated from typical "nail head" spot. Tomato fruit from Florida.

B. *M. solani.* From culture marked 19–173. Isolated from tomato plants affected with "foot-rot" from Delaware.

C. *M. solani.* From culture marked 17–57. Isolated from potato seedlings from Maine.

D. Saprophytic Macrosporium. From culture marked 19–148. Isolated from green tomato fruit from Florida.

E. *M. tomato.* From culture marked 18–110. Isolated from spreading "nail head" spot from Florida tomatoes as shown in plate II. Fig. A.

F. *M. solani.* From culture marked 19–134. Isolated from potato leaves from Maine.

G. *M. solani.* From culture marked 19–130. Isolated from tomato fruit rot from New Jersey.

H. *M. tomato.* From culture marked 19–154. Isolated from "nail head" spot from Florida tomatoes. The body of these spores are larger than the average *M. tomato* from "nail head" spots but similar in the terminal beak, in cultural characters, and in pathogenicity.

Consideration of the facts brought out in these comparisons shows without a doubt that the Macrosporiums producing typical "nail head" spots on fruit, stems, and leaves, as represented by cultures marked 17–19, 18–110, 19–154, and 19–170, are different from *M. solani* from potatoes, represented by cultures 17–57 and 19–134. They are also different from 19–130 from New Jersey tomato fruit, and 19–173 from Delaware tomato stems. The latter two cultures agree very closely with *M. solani* from potatoes and should be referred to as such. The above results may possibly explain the apparent discrepancy between the conclusion drawn by Rands (4) and Kunkel (7) as regards the identity of the Macrosporium from tomatoes with *Macrosporium solani* from potatoes. Kunkel (7) refers to the Macrosporium from tomato as *M. tomato*. This specific name is considered a synonym by Jones and Grout (6) for *Alternaria fasciculata*, which is not parasitic on the tomato. The spore measurements as given in the original description by Cooke (10) agree fairly well, however, with the spores obtained from typical "nail head" spots. It is, of course, hard to determine whether Cooke's *M. tomato* is identical with those obtained from "nail head" spots. In view of this fact, however, that it is undoubtedly different and distinct from *M. solani* on potatoes, *M. tomato* Cooke is to be preferred. In the cultures studied here all Macrosporiums isolated from typical "nail head" spots, such as 17–19, 18–110, 1–147, 19–154, and 19–170, should be referred to as *M. tomato*, while 17–57, 19–130, 19–134 and 19–173 should be referred to as *M. solani*.

SUMMARY

1. Numerous counts made in the field and inoculation experiments in the field and laboratory have shown that infection on tomatoes resulting in typical "nail head" spots takes place without previous injury to the fruit. Such infection, however, takes place only on immature fruit not more than approximately six inches in circumference.

2. Experimental shipments of winter-grown tomatoes from the South, together with artificial inoculation experiments on tomato fruit of various maturities as indicated by size, have shown:

a. That the disease commonly referred to as "nail head" spot does not originate in transit on mature fruit picked from an infected field.

b. That immature fruit, that is, fruit less than six inches in circumference picked from an infected field and shipped without delay, may develop numerous Macrosporium or "nail head" spots in transit.

c. That the disease does not spread from one infected fruit to an adjacent fruit during transit.

3. Isolations made from numerous diseased tomato fruit, stems, and leaves from Florida and other tomato growing sections have shown that the same kind of a lesion is generally produced by the same Macrosporium.

4. Cultural and morphological comparisons of all the Macrosporiums obtained from tomatoes with *Macrosporium solani* E. & M. from potatoes show that:

a. Typical "nail head" spots on fruit, stems, and leaves are caused by a Macrosporium different specifically from *Macrosporium solani* from potatoes. For reasons pointed out in the text, the Macrosporium causing such spots should be referred to as *M. tomato* Cooke.

b. A stem disease occurring in Delaware and a fruit rot of tomatoes in New Jersey are caused by a Macrosporium which resembles *M. solani* in culture, in morphology and in its pathogenicity. It should therefore be referred to as *M. solani* E. & M.

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PLATE II. MACROSPORIUM ("NAIL HEAD") SPOTS ON TOMATO STEMS AND FRUIT

The stem and fruit show typical "nail head" spots as a result of natural infection in a field near Miami, Florida.

ROSENBAUM: TOMATO MACROSPORIUM

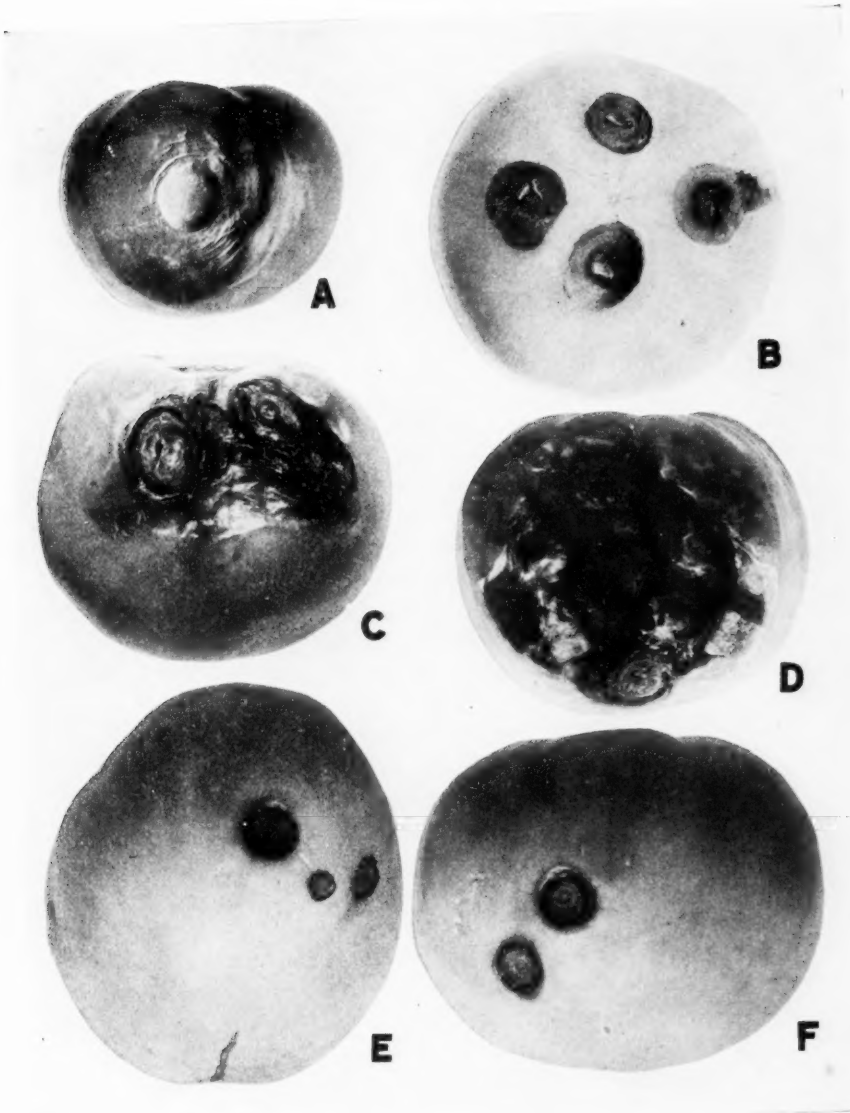
PLATE III. LESIONS ON TOMATO FRUIT DUE TO MACROSPORIUM

Fig. A. Natural infection on ripe tomato showing a spot which has been referred to in the text as a "spreading Macrosporium spot."

Fig. B. Lesions produced artificially by inoculating with Macrosporium from tomato fruit collected in New Jersey.

Fig. C and D. Old Macrosporium spots which show secondary infection by other organisms.

Fig E and F. Typical "nail head" spots on tomato fruit from Florida.



ROSENBAUM: TOMATO MACROSPORIUM

CAUSES FOR THE PRODUCTION OF PATHOLOGICAL XYLEM IN THE INJECTED TRUNKS OF CHESTNUT TREES

CAROLINE RUMBOLD

WITH PLATES IV AND V

In the course of an investigation the writer studied the causes for the production of the extra xylem which was found in the phloem region of chestnut trees into which chemicals had been injected.

GENERAL APPEARANCE OF INJECTED TISSUES

The appearance of this pathological condition of injected tree trunks was described in detail in a previous paper (3). It is in part as follows:

"So far, an examination of chestnut trees injected with chemicals in solution shows that the reaction in the trunks and branches, as evidenced by abnormal tissues, was alike in kind, but varied in intensity."

"With increased distance from a point of injection the tissues became more normal and the area of disturbance decreased. All stages of reaction could be seen in a tree: death, inhibited growth, stimulated growth, and no reaction."

"The regions of response were the phloem, cambium, and xylem."

"*The phloem.* The most remarkable response from a histological standpoint was that given by the phloem region. Xylem cells formed in the midst of the phloem region. This xylem was formed by division of the phloem cells with subsequent lignification of the walls, or by lignification of the phloem cell walls without division. All the cells in the phloem were capable of change except the stone cells, the bast fibers, and those cells containing calcium oxalate crystals, which accompany the bast fibers."

"The phloem cells changed into bark cambium, cambium, and xylem cells."

"Cork formed prematurely, due to an unusual development of bark cambium in the phloem region."

"*The cambium.* The cambium layer often disappeared. Its cells changed into xylem."

"*The xylem.* The xylem responded by increased formation of tyloses and thickening of cell walls."

"*Wound tissues.* Wound tissue formed, which varied from normal to abnormal according to the toxicity of the solution injected."

To make clear the idea presented in this paper, a statement is given of what is meant by pathological tissue and by normal and abnormal wound tissue. All wound tissue is pathological in that it does not naturally appear in the tissues of a healthy, uninjured plant. But wound tissue when it does appear in a plant can in turn be normal and abnormal. For example, it is normal when in a clean cut, uninfected wound the surrounding tissues produce in regular sequence the callus or wound tissue which in time occludes the cut. If for some reason this regular sequence in the production of wound tissue is interfered with, the tissue produced is abnormal and presents an unusual picture to the eye of the pathologist in that it is made up of plant cells of unnatural shape or in unusual juxta-position.

The location and general appearance of the extra xylem can best be shown by two typical sections of injected trees.

Plate IV, fig. 1. A section cut from a tree injected June 20 to October 6 with lithium carbonate 1/500 G. M. and felled in November of the same year. The section was cut from a block situated about 2 inches above a place of injection and a little to one side of the path of the solution.

The side marked + was nearest the path of the solution. On this side dead cells and plugged medullary rays were more numerous. The extra xylem cells usually were normal in shape. The connection between the normal vascular system of the tree and the strand of xylem nearest the original cambial region can be seen at the extreme left. Beginning in the center of the picture the extra xylem strands included small patches of phloem cells. Their cells were increasingly non-typical in shape, many of them phloem cells with lignified walls. On the right hand side the number of dead cells and plugged medullary ray cells in the original xylem tissue had decreased.

Plate IV, fig. 2. A section cut from a block about $6\frac{1}{2}$ inches below the place of injection and at the edge of the path of the solution. The tree was injected with nitro phenol, (para), 1/1000 G. M. during the latter half of May and in June and was felled in November of the same year.

The side marked + was in the path of the solution. Many of the cells in the cambial region here were injured or killed and callus cells had developed next to the injured region. There were also many dead cells in this callus region. At the outer edge of the callus was a strip of original phloem cells with lignified walls and beyond this a broad strand of xylem cells of typical form. Beginning in the center of the section and passing

to the right, the callus disappeared, also the dead cells. The path of the solution could no longer be detected. On the right hand side of the section could be seen in the center of a typical xylem tissue a strip of abnormal xylem, consisting of lignified phloem cells mingled with typical xylem ones. The cambium layer was again normal.

CAUSES STATED

There are two main causes for this development of xylem in the phloem region: (1) The mechanical severance of the vascular tissues; (2) the chemical stimulation of the cells.

I. THE MECHANICAL SEVERANCE OF THE VASCULAR TISSUES

Review of literature

Much study has been given to the effect of severing one or more tissues of the vascular system of plants and there is now extensive literature on this phase of experimental morphology. It will be found compiled in Kuster's Pathologische Pflanzenanatomie (1), but it is of value to summarize here at least four of the most important papers, which show the results of mechanical severance of a part of a plant's vascular system.

Hugo de Vries (8) studied the formation of wound wood on a variety of trees. By ingenious methods he succeeded in severing successively the phloem, the cambium, and the newest rings of wood without injury to the other tissues. He found:

a. The cells of all tissues formed nearest a transverse wound were shorter than normal ones and lengthened with distance from the wound until they attained their normal length.

Cuts made parallel to a stem axis produced cells of normal length.

b. A transverse cut of young wood cells made without injury to the other tissues produced callus and, later, wound wood gradually developed.

c. A transverse cut of the cambium alone produced callus and wound wood. In the latter were strands of vessels which connected the normal wood both above and below the wound.

d. A transverse cut of the inner phloem made from the inner side (next the cambium) produced wound wood as in the case of the severing of the cambium. But when the cut was made from the outside, however, and the cambium was uninjured, callus was produced.

e. Lessening the tension of the bark increased the number of vessels and the diameter of all cells, whether the cut was parallel to the axis of the branch, across it or oblique to it. No wood fibers were formed in the wound wood if the longitudinal tension of the cambium tissue was diminished.

f. The nearer the wound, the smaller and more numerous do strands of vessels become. With an increase in the distance of the tissue from the wound the strands of vessels tend to coelesce and finally connect with the normal xylem (see de Vries' illustration, fig. 14, plate 2).

Vöchting (7), by transplanting or removing organs of plants, demonstrated the röle that the polarity of plants played in the direction which these newly formed strands of vessels took in connecting the severed strands. When the plant was in a normal position the "bridge" or strand of vessels binding the two ends made as short a line as possible. With increasing variation from the usual position of the plant, the directness of the connecting strand diminished.

Simon (5) found by means of ringing or by partly severing the stems of young plants that the first reaction to a transverse wound was the formation of callus, first on the upper, then on the lower side of the wound. Very shortly after this callus formation appeared strands of vessels which were either tracheids or true vessles. In case the wound was made in tissue so young that the cambium had not begun its activity, the vessels appeared before the meristematic cells. These strands formed first near the ends of the severed strands.

In the case of a wound made by transversely severing a portion of the vascular system of a plant, the reunion of the cut vascular tissues proceeded as follows. The strands of vessels formed first on the upper side of the wound at the basal ends of the normal strands of vessels, and then at the apical ends of the strands on the lower side. These vessels often were formed by a direct conversion of cells without previous cell division. A little later a meristematic strand of tissue formed just back of the callus which covered the surface of the wound. In this meristematic tissue vessels appeared, and later the usual phloem and xylem cells. In this manner a "bridge" was formed for the flow of the sap.

Neeff (2) studied the effects of removing the terminal bud from sprouts which were thus forced to continue their length growth from a secondary bud near the tip. He also studied the effects of transverse cuts through parts of the vascular system. Cambium, phloem, and xylem were affected.

a. Cambial cells in the neighborhood of the wound divided into short cells. This tissue then proceeded to grow in the direction of the secondary bud, which then replaced the terminal bud. Its cells formed wood and bast parenchyma. It developed vessels and sieve tubes by the absorption of lateral cell walls. These atypical strands sometimes ran at right angles to the original direction of the cells, cutting through medullary rays lying in their path. A cambium layer gradually developed phloem and xylem cells, both groups of elements becoming more normal in shape the farther removed they were from the wound. Transverse wounds of the vascular system of young sprouts produced the same results.

b. After the operations, short, dividing cambium cells (Neeff's nomenclature) developed in the phloem region. This tissue developed as described in *a*. In the development of the connecting "bridge" phloem cells were converted without cell division. Bast fibers developed pits. Cells of the medullary rays were changed into short sieve tubes and companion cells. The medullary rays were cut into small parts by these developing strands.

c. The xylem region produced a dividing cambial layer which developed abnormal wood. This wood was at first composed of wood parenchyma; later fibers developed. Strands of vessels were found which grew at right angles to the original direction of wood cells. If the wounded xylem tissue was young, the growing cambium layer developed the usual vascular elements for sap transportation. But before these strands were developed, the old wood cells were used in the transportation.

These descriptions formed a picture complete enough to show the processes by which a plant recovered from a mechanical wound which severed a part of its vascular system. There would have been no need for further work had not some experiments made by Schilberszky (4) appeared to disagree with the results described above and apparently agreed with some of those attained by the writer, i.e., the formation of xylem cells on the outer side of the hard bast.

Schilberszky stated that extra fascicular vascular bundles could be formed on the outer side of the hard bast cells in seedlings of *Phaseolus multiflorus* and *P. vulgaris*. This new tissue developed by the activity of the starch sheath or endodermis, which acted as a cambium layer, producing phloem cells on its outer side and xylem cells on its inner. He produced this result by cutting out a part of the seedlings' stems when they were actively growing.

An attempt was made by the writer to repeat Schilberszky's experiments. This could not be done exactly, for the reason that seed of *Phaseolus multiflorus* or *P. vulgaris* could not be obtained at the time the work started. Instead seedlings of the vetch, *Vicia faba*. were used, as were a few seedlings of an edible pea, of castor bean and young shoots of *Polygonum sieboldii*. Schilberzsky's result was not obtained, i.e., the conversion of the endodermis into a cambium layer, such as he figured in figure 5, Plate XXII (4).

Experiments with Vetch seedlings

Results of interest, however, were obtained with vetch seedlings. At a period of rapid growth a segment $\frac{1}{2}$ inch long was removed from the stem of a seedling, leaving but one-half or one-third of the cylindrical stem through which the sap could flow. This remaining segment of

stem responded by forming a callus over the cut surface. Behind this callus formed a meristematic layer connected with the cambium of the old vascular system. This layer in time produced phloem and xylem cells and thus reformed as nearly as possible the original circular vascular system. During this time the vascular elements left in the segment of stem increased in quantity by secondary growth. These results were duplicated with seedlings of pea and castor oil bean, and with shoots of Polygonum.

The nearest approach to Schilberszky's results was obtained when so large a segment of the seedling's stem was removed that the wound was next to the xylem cells and few of any pitch cells were left. In this case a meristematic layer of cells formed just outside the hard bast just as is pictured in Schilberszky's figure 3, plate XXII (4). But this meristematic layer, as Schilberszky apparently failed to see, was connected with the original cambium layer. Later some vessels developed in this new formed meristematic layer but at right angles to the normal direction of the cells. Serial transverse sections of such stem segments demonstrated this connection of the meristematic and newly formed vessels with the old vascular system. They could be seen passing between vascular bundles to the position outside the hard bast cells. The experiments did not show that the endodermis or the region about it was, in and of itself, especially active in growth, but that all the cells in the vetch seedlings' stems, except the hard bast cells, were capable of growth when they lay near a wound.

Summary

When there was a mechanical severance of growing vascular tissues (and here no chemical was introduced), new passages for the sap were formed invariably. When the plant was in a normal position such new passages always connected the severed ends and took a nearly direct route.

These conclusions are based on experiments of de Vries, Vöchting, Simon, and Neeff, and have been confirmed by the writer. The only one of the authors here considered who did not agree with this statement was Schilberszky. His observation that there were new formed vessels outside the hard bast region was right, though only in such cases where so large a section of the seedling's stem was removed that little if any pitch cells were left. However he failed to see the connection between these vessels outside the hard bast region and the normal vessels, and so did not realize the part they played in the transportation of the sap.

Condition of injected trees

When comparing the results obtained from cutting with a knife through a part of the vascular system of a plant with those obtained by injecting it with chemicals, it should be remembered that these results varied, because the effect of the chemicals varied and also because there was a variation in the effect of a solution in an injected tree due to the retention of the chemical by the cell walls and the consequent increasing dilution of the passing stream.

An examination of the trees showed:

a. If the solution killed, but did not spread rapidly through the tree, then a splitting of the bark occurred along the path of the solution and a typical callus formed such as would have developed had the bark been cut by a knife. The more toxic the solution the more normal the wound tissue.

Sometimes a hole was worn in the young wood by the passing solution. If the cells surrounding the hole were alive the hole was filled by a callus growth.

b. If the solution was less toxic than the one described in *a*, it stopped the growth of the new wood, the cambium and inner bast, either one, two or all three of the tissues, according to its toxicity and to the path of the solution. Here wound wood formed which connected the severed or blocked vascular tissues. But instead of wound tissues such as formed about a cut, wound tissue formed in a narrow area extending up and down the tree, often for a number of feet.

c. If the solution did not injure or inhibit cell growth, it caused an irregular growth of cells. This showed itself in the phloem region in atypical lignified cells formed in irregular strands which connected with the normal xylem tissue. This third phase of the results from tree injection was caused by chemical stimulation.

II. CHEMICAL STIMULATION OF CELLS

Smith's experiments with chemicals

The paper "Mechanism of Tumor Growth in Crown Gall" recently published by Erwin F. Smith (6) showed to what an extent the presence of certain chemicals could excite plant cells. His figures (6) on plates 56, 58, 59, and 61 showed these effects most clearly. They showed intumescences produced on the under surface of cauliflower leaves when exposed to the vapor of a mixture of ethyl alcohol and acetic acid. Here there could be no question of a severance or blocking of the original vascular system of the plant, by a bruise, or a cut. Chemical irritation

at a single point on the leaf had continued long enough to produce cell growth and division. This activity had been followed by the formation of conducting tissue connecting the growing region with the normal vascular system. In Smith's illustrations, figures 3, 4, and 5, plate 58, showed transverse sections of these intumescences and figure 1, plate 61, a longitudinal section, in which incipient vessels could be seen entering the region of actively growing cells.

The extent to which chemical irritation could produce extra vascular tissue was shown by Smith's illustrations on plates 37, 38, 39, 40 and 41, where the injection of a 5 per cent solution of monobasic ammonium phosphate into an internode of a castor bean seedling had caused the formation of a second vascular system in the pith cells lining the hollow internode.

Experiments with Polygonum and Vetch seedlings

The writer produced a result similar to Smith's with the castor bean seedling, but less fully developed, by exposing the cavities of internodes of young shoots of *Polygonum sieboldii* to the stimulation of air. This was done by removing a segment of stem from an internode. The exposed pith cells lining the cavity formed a callus. Behind this developed a meristematic layer in which vessels appeared. These vessels connected with xylem cells in the normal vascular system.

In order to compare more readily the difference in results between mechanical severance of the vascular tissues and that produced by the injection of chemical solutions, experiments were made with vetch seedlings. During a period of rapid elongation, these were injected by means of a hypodermic syringe. The solutions of chemicals (circa 1 cc.) were introduced in the internodes with as little injury to the stems as possible. When examining the injected plants the region around the place of injection was discarded. The following results were obtained:

a. When the solution killed the tissues a meristematic tissue cut off the dead cells from the living. If part of the vascular tissue was killed new tissue developed. (Example: mercuric bichloride 1/500 G. M.).

b. When the solution inhibited cell growth (near the place of injection), the result was the formation of a meristematic layer, and (1) cells at a distance showed little if any response (picric acid 1/10000 G. M.); (2) cells at a distance showed irregular division (example: thymol 1/1000 G. M. and to a much greater extent cell division was produced by sodium hydroxide 1/50 G. M., lithium nitrate 1/50 G. M. and Knop's solution).

c. When the solution produced no effect (distilled water).

These effects obtained in the vetch seedlings were very irregular compared with those produced with the knife.

In the results described under *b*, the cells in the cortex and pith regions divided once, twice and sometimes three times and generally showed large nuclei. No vessels were noticed among these dividing cells. The cells of the vascular bundles were unchanged, but many of the cells in the neighborhood of the cambium contained unusually large nuclei. This especially was the case in those stems injected with Knop's solution. These effects produced in the seedlings by the small amount of chemical solution injected, about 1 cc. in a plant, were regarded as a first phase of cell response to the irritation caused by the presence of a chemical.

When there was a chemical stimulation of plant cells, they responded by cell division and sometimes growth. In case the stimulation was sufficiently pronounced, the resulting region of actively dividing cells developed vessels which connected with the normal vascular system of the plant.

With continued stimulation more fully developed xylem tissue formed.

Examination of injected tree trunks

An examination of injected trees was made by sawing the trunks into sections and then following the path of the solution up and down the tree from the injection hole to the point where phloem, cambium, and xylem regions were normal in appearance. Blocks of wood were removed from these sections at varying distances from the injection hole, both in the path of the solution and at the side. Microscopical slides were prepared from these blocks.

These slides showed that the greatest amount of extra xylem, i.e., xylem in the phloem region, was in the neighborhood of the injection hole and the killed tissue extending up and down the tree from the hole. In general the extra xylem cells in this region were normal in shape and developed in numerous strands of uniform cells which ultimately united with the normal vascular tissue. See fig. 1, plate IV toward the side marked +. Figure 1, plate V shows an enlargement of a part of a cross section of a strand or bridge of xylem (as in fig. 1, plate IV, showing the development of normally shaped xylem cells on the outer side (nearer the bark) of a row of bast fiber cells. On the inner side of the bast fiber row the walls of the medullary ray cells are partially lignified, but have not changed their size and shape.

The slides also showed the presence of extra xylem cells of normal shape and small size in the phloem region when the cells of the regular xylem were normal in appearance, where no sign of an occlusion of the tissue was visible and where the place itself was so far removed from killed tissue

there could be no question of effect from severed vascular tissues. Figure 2, plate V shows a longitudinal radial section of such a region.

In this region there also were extra xylem cells which were phloem cells with lignified walls, also usually arranged in irregular strands. Frequently in these xylem strands there were groups of phloem cells with intercellular species in their midst. This pathological tissue connected with the normal vascular system of the tree. Such tissue can be seen in figure 1, plate IV on the side marked 0. It can also be seen in the center of figure 2, plate IV.

In the great majority of cases the injected trunks showed that this region containing irregular or extra xylem was, comparatively speaking, a small one. Usually pathological tissues could not be seen more than two feet from the injection hole. This was partly due to the fact that when the trees were injected an endeavor was made not to kill them by the treatment and consequently the chemical solutions used were dilute.

SUMMARY

The causes for the production of pathological xylem in the phloem region of the trunks of injected chestnut trees is two-fold: (1) The mechanical severance of vascular tissues; (2) the chemical stimulation of cells.

1. The xylem is caused by a mechanical block formed in the neighborhood of the wound; in such a region meristematic cells and vessels arise. The vessels develop from new meristematic cells and from local cells. Strands of such meristematic cells and vessels connect the severed ends of the vascular tissues. The above mentioned facts have been brought out by the experiments of de Vries, Vöchting, Simon, and Neeff, and have been confirmed by the writer's experiments with seedlings.

2. The xylem, due to a chemical stimulation, forms in the neighborhood of cells which have begun dividing and connects that growing region with the regular vascular system. This procedure of cell growth was brought out by Smith's results from subjecting cauliflower leaves to chemical vapors and by the writer's from exposing the interior of young Polygonum internodes to the air.

The writer's examination of tree trunks injected with various chemicals shows that frequently the two factors, mechanical severance of vascular tissue and chemical stimulation, act simultaneously in the formation of strands of pathological xylem in the phloem region. Observation, however, also shows that a mechanical obstruction in the vascular tissues results in a more regular formation of strands of xylem cells than when they are caused by chemical stimulation.

The writer finds that at a marked distance beyond injured or discolored tissues, irregular strands of xylem are found in the phloem region, strands composed of irregularly formed cells and of irregular formation. This formation is not caused by a severance of a part of the tree's vascular tissues, but by a chemical stimulation.

INVESTIGATIONS IN FOREST PATHOLOGY
BUREAU OF PLANT INDUSTRY,
UNITED STATES DEPARTMENT OF AGRICULTURE

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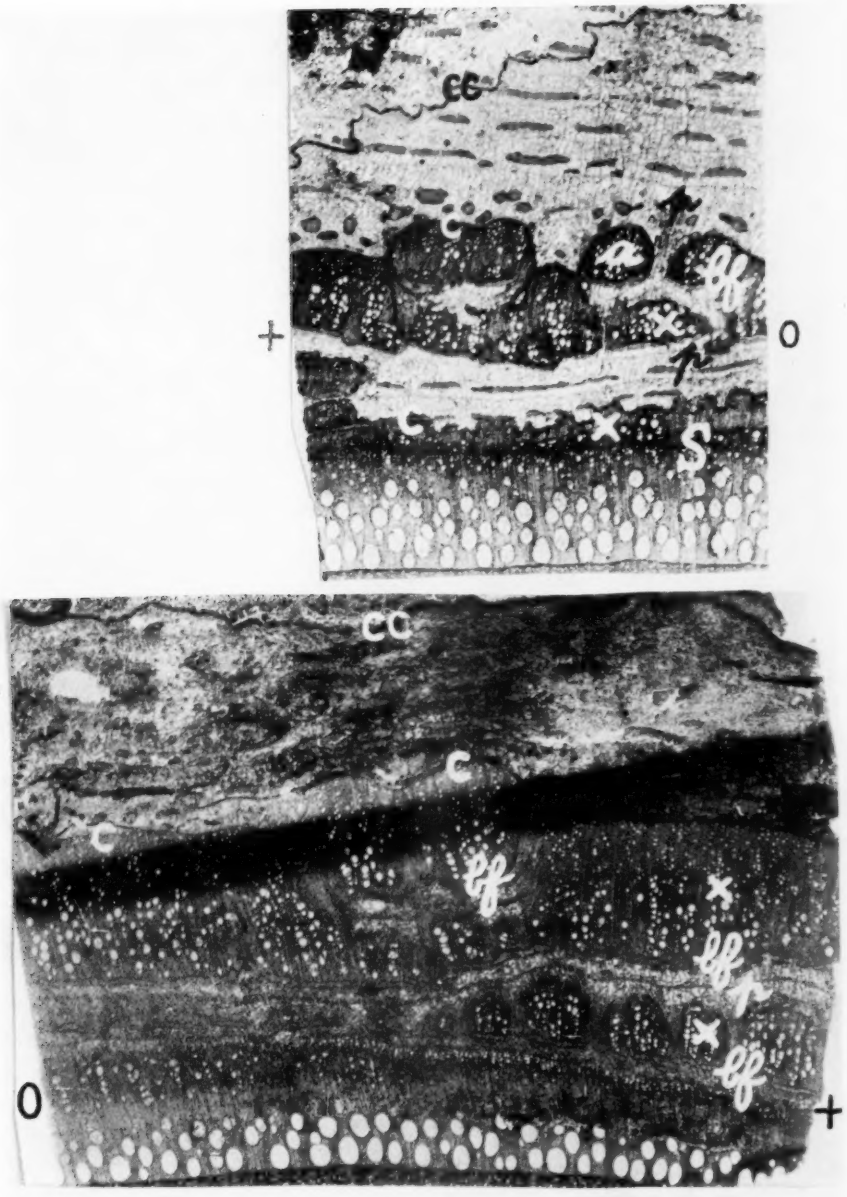
PLATE IV

FIG. 1. Tree no. 21C, injected with lithium carbonate, 1/500 G. M. Cross section of bark and wood. *p*, phloem; *x*, xylem; *c*, cambium; *cc*, cork cambium or bark cambium; *bf*, bast fibers; *a*, extra strand or bridge of xylem in the phloem region; *s*, stain caused by the injected lithium salt. (See text p. 24.)

FIG. 2. Tree no. 143E. Injected with nitro phenol para 1/1000 G. M. Cross section of bark and wood. *p*, phloem; *x*, xylem; *c*, cambium; *bf*, bast fibers. (See text p. 24.)

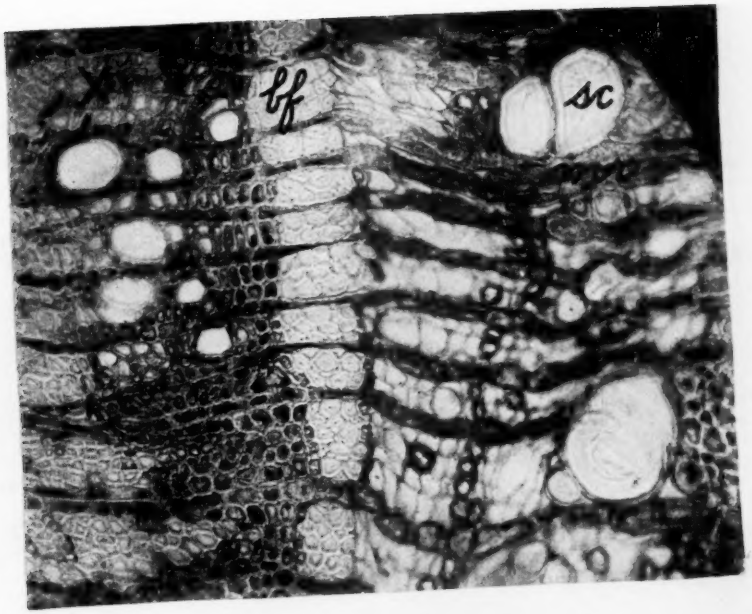


RUMBOLD: PATHOLOGICAL XYLEM

Plate V

Fig. 1 Enlargement of strand of wood in the phloem region marked *a* in figure 1, plate IV. The inner region of the strand of xylem, showing the development of zylem cells on the outer side of a row of bast fiber cells. The large openings in the xylem are tracheae. *x*, xylem; *bf*, bast fiber cells; *mr*, medullary ray cells; *sc*, stone cells.

Fig. 2. Tree no. 21C. Longitudinal radial section of strand of xylem in phloem region. The left of the picture is nearest to the outer bark, the right of the picture nearest the wood rings. *sc*, stone cell; *x*, xylem cell; *t*, trachea; *bf*, bast fibers.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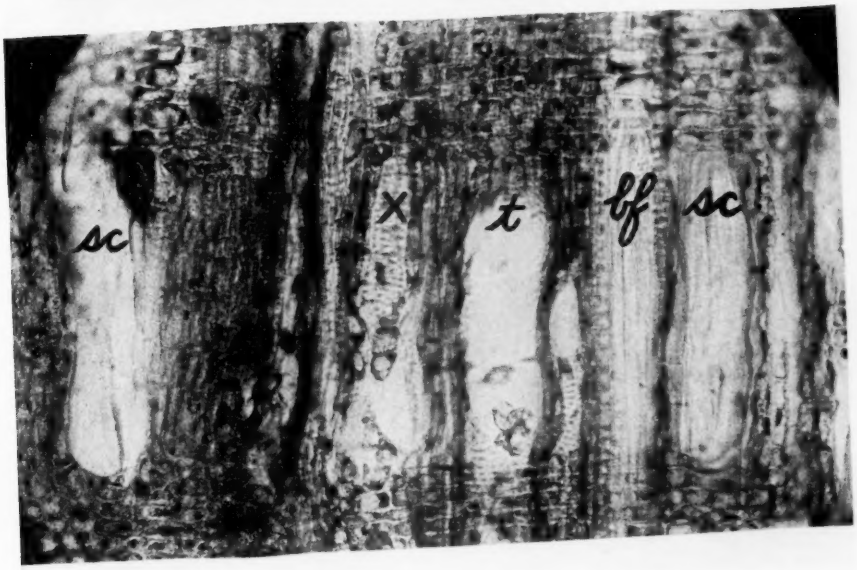
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THE MOSAIC DISEASE OF THE SOLANACEAE, ITS RELATION TO THE PHLOEM-NECROSIS, AND ITS EFFECT UPON POTATO CULTURE

H. M. Quanjer

With Fourteen Figures in the Text

The "curl" of potatoes is an old disease which hitherto has been connected by earlier authors with degeneration or senility of the variety. In the beginning of this century Dr. O. Appel made it clear that the term "curl" has been applied to a number of distinct diseases; he set apart a particular form which he called "leaf roll;" for another type he retained the old name "leaf curl" (Krauselkrankheit). This last type is the same which is called "curly dwarf" in America. Another form related to this group is described in America as "mosaic" (Orton, 1914).

The first requisite for experiments on the contagiousness of these diseases is a great quantity of reliable healthy plants. Since these diseases are widely spread in the fields it is necessary to cultivate healthy plants on a large scale. It is the merit of Oortwyn Botjes to have detected the mode of dissemination in the field and to have based on it a method of cultivating disease-free plants.

The writer has studied the histological and physiological side of the problem. He detected phloem-necrosis in 1908 and described it for the first time in 1913, after having made observations on it in strains of potatoes of the variety Paul Krüger and some other varieties cultivated during five years. He has come to the conclusion that the old conception of "leaf curl" contains two distinct diseases.

1. Leaf-roll, which may better be termed phloem-necrosis or, according to Pethybridge, lepto-necrosis. It is contagious and pseudo-hereditary (Quanjer, V. D. Lek, and Oortwyn Botjes, 1916), and by means of these peculiarities distinguishable from pseudo-leafroll caused by soil influences. Moreover, it is characterized by necrosis of the phloem strands and is thereby discernible from foot and wilt diseases (Quanjer, 1913).

That the phloem cells are affected in cases of leaf-roll is confirmed by Dr. E. Artschwager (1918), though he believes there are exceptions. The writer is convinced, as far as the variety Paul Krüger is concerned, that phloem-necrosis is the only internal symptom which distinguishes true leaf-roll from a number of other pathological conditions which have

some resemblance to it and which might have played a part in Artschwager's one year's observations.

2. Leaf-curl (curly dwarf). This may be called more appropriately mosaic, as it is the intense form of the latter disorder. In several varieties of potatoes Oortwyn Botjes and Quanjer have observed that healthy plants exposed to contamination by neighboring mosaic or curly dwarf plants show in their progeny the first faint symptoms of mosaic, which accumulate and pass into the well-known curling and dwarfing in the following generation (figs. 4 and 5).

There is a good deal of analogy between phloem-necrosis and mosaic. These diseases are not discernible, or if so very slightly, in the year in

FIG. 1. At the left, six halves of healthy tubers, the other half of each of which has been transplanted to a half diseased tuber (in the center). At the right, the six control halves of the diseased tubers. The transplanted halves grow into one by means of the phloem portions of their vascular rings. After being planted the shoots of the sound halves will prove to be contaminated.

FIG. 2. In the center is shown a combination of a sound half and a diseased one; the other halves are to be found at the left and right.

which infection occurs. In the case of phloem-necrosis sometimes and in some varieties it may be recognized in a mild form in the upper parts of the plants as "primary leaf-roll;" in the progeny of the primarily infected plants the disease develops in its intense or "secondary" form, which admits of a reliable diagnosis. The same thing holds good with regard to the mosaic disease. In a primarily infected plant the symptoms are not discernible to an appreciable degree; even in the direct progeny it may vary from a scarcely discernible form to intense mosaic; in the following generation the mosaic may be coupled with a curled or dwarfed habit. In very sheltered places the more intense form does not develop,

FIG. 4. *A*, PLANT OF VARIETY EIGENHEIMER WITH THE "CURLY-DWARF" FORM OF MOSAIC; *B*, A HEALTHY PLANT OF THIS VARIETY

FIG. 5. *A*, PLANT OF VARIETY EIGENHEIMER WITH THE MILD OR MOSAIC FORM OF DISEASE; *B*, PLANT OF THIS VARIETY WITH THE "CURLY-DWARF" FORM.

as is the case with phloem-necrosis. So the progress of mosaic in several varieties is slower than that of phloem-necrosis.

That both phloem-necrosis and mosaic are contagious can be proved by grafting diseased scions on healthy stocks or by transplanting halves of diseased tubers on halves of healthy ones (figs. 1 and 2). The same methods have been used in order to prove that different forms of mosaic, varying according to the variety of potatoes, are indeed the very same disorder.

The chief sources of infection by phloem-necrosis and mosaic in the field are neighboring plants (fig. 3), (Oortwyn Botjes 1916). In figure 3 the upper row of circlets represents a row of plants growing in 1917 on heavy clay, being the progeny of one plant. This row was planted in an isolated place, so that infection could originate only from diseased plants in the row itself. The two blackened circlets are plants attacked by phloem-necrosis, the six gray ones by mosaic. Of one of these (the sixth),

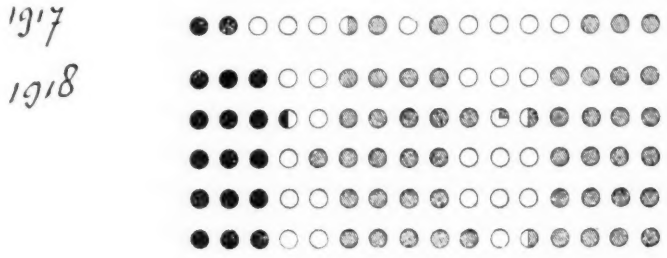

FIG. 3. DIAGRAM ILLUSTRATING FIELD SPREAD OF MOSAIC AND PHLOEM-NECROSIS

a portion of the stalks are mosaic. Under each of the circlets a vertical row of five circlets is drawn, representing the asexual progeny in 1918 of the corresponding plant in 1917. It is seen from the progeny of 1918 that phloem-necrosis has spread in 1917 to the next neighbor and has infected even the following neighbor so slightly that the disease is appreciable only in some sprouts of one plant of its progeny. The extension of mosaic to the neighboring plants occurred in an entirely analogous way; the partially infected plant has an entirely diseased offspring. Generally the mosaic proceeds to the next neighbor; in exceptional cases the following neighbor also is infected. On heavy clay soil only the very nearest neighboring plant was infected. On light sandy or peaty soils the infection passed on to the third, fourth, or fifth plant, or to a distance of 2 or 3 yards. In an experimental way it has been shown that as a rule the infection passes through the soil, not through the air. This is illustrated by figure 6, where the two vertical rows of circlets represent each a row of five mosaic plants of the variety Paul Krüger, growing on

sandy soil; the two horizontal rows are healthy plants of the variety Bravo. In the left plot an iron partition was fixed into the soil to a depth of above one yard; in the other plot (situated at some distance) the roots of the healthy and diseased plants could intertwine. The next year the whole progeny of the Bravo of the left plot was still healthy; the whole offspring of the Bravo of the right plot was diseased.

In 1915 a row of tubers attacked by phloem-necrosis and a row of healthy ones was planted side by side (at the left) (fig. 7). Between them and above the ground a double wire was erected so that the roots could reach each other but the vines could not. On another plot (at the right)

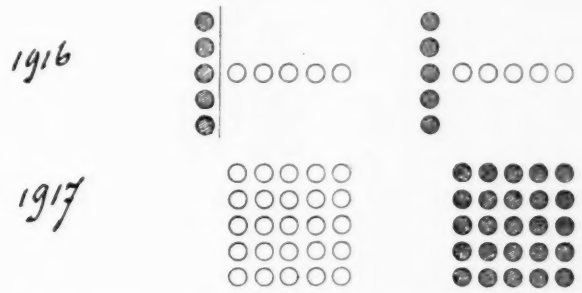

FIG. 6. SPREAD OF POTATO MOSAIC THROUGH THE SOIL

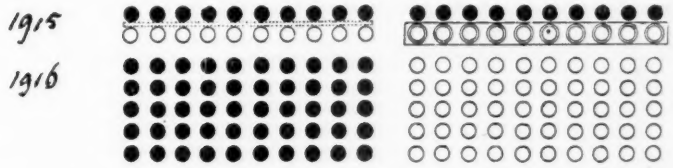

FIG. 7. SPREAD OF POTATO PHLOEM-NECROSIS THROUGH THE SOIL

a row of tubers attacked by the same disease was planted at the side of a trench in which healthy plants were placed in pots. Each pot was wrapped in "wood-wool," so that the roots could not reach those of the diseased plants; the vines, however, could touch each other. In 1916 all the healthy plants of the first plot had a diseased progeny, whereas all the pot plants of the other plot had healthy offspring.

In the experiment illustrated in figure 8, cells, zinc below, glass above, contained two potato plants, a healthy one and a leaf-rolled one, growing side by side. In the first two cells the roots could join but the "vines" were separated by a glass partition. In the following two cells the roots were separated by pots so that the foliage could touch. In the last two cells both roots and vines were separated. The result in 1916 was that contamination had occurred only where the roots could intertwine.

In figure 9 is illustrated the same experiment on mosaic. In each pair of cells the varieties "Blauwe" and "Eigenheimer" have been alternately used as source of infection. The healthy plants, which were exposed to infection, were of the variety Eigenheimer. No matter which variety was used as the source of contamination, the Eigenheimer in every case caught the disease where the roots were exposed to it; it did not where

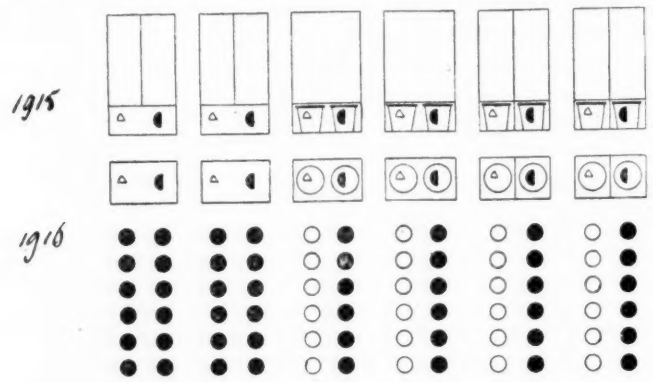

FIG. 8. SPREAD OF POTATO LEAF-ROLL

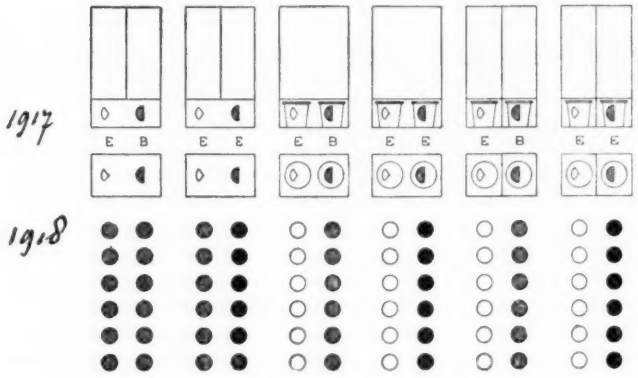

FIG. 9. SPREAD OF POTATO MOSAIC

the foliage was exposed. From this it is clear that the mosaic of either variety is identical. When in 1917 the Eigenheimer used as source of infection had the mild or "mosaic" form of disease, in 1918 it had developed into the "curly dwarf" form (indicated by a darker gray color). The newly infected plant had the weak mosaic in 1918. So the progression from mosaic to "curly dwarf" has been proved. When these experiments were repeated in 1918 the result was the same as concerns subsoil in-

fection, but some of the plants which were exposed to above ground infection only, also caught the disease as was to be seen from their progeny in 1919. The variety Blauwe is not able to assume the "curly dwarf" form. Although it may be severely diseased, the disorder will still be expressed as mosaic.

The question arises whether the contagia (virus or more probably ultramicroscopic parasites) causing these diseases can live in a saprophytic condition in the soil from the moment that it has been deposited there by diseased plants till the time when a new crop of potatoes is raised. The experiments undertaken to solve this question at Wageningen, in the southern part of our country, have not led to any uniform results in the case of phloem-necrosis. It is to be borne in mind that it is very difficult

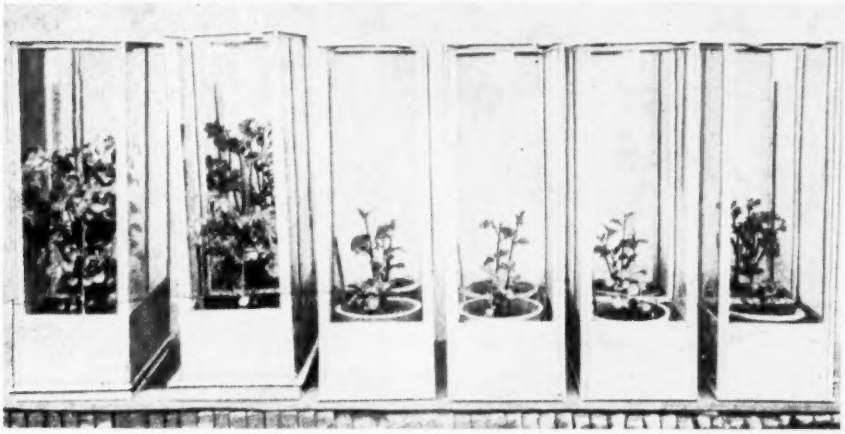

FIG. 10. PHOTOGRAPH OF THE CELLS REFERRED TO IN FIGURES 8 AND 9

to determine whether primary infection has occurred by observing the mild symptoms of this disease in the upper parts of the plant, as the latter may be easily confounded with injury due to soil conditions or to attack of the subterranean parts by various parasites. Therefore not only the plants of the experiment itself, but also the progeny of each of them has always been observed. The writer's first experiment in 1915 on soil infection with phloem-necrosis, on plots which had borne diseased plants some years previous, led to positive results. Control plants on plots where potatoes were never grown kept healthy, but when these experiments were repeated in 1917, after a very severe winter had killed all living parts of the potato plant to a great depth, the existence of soil infection could not be proved. Oortwyn Botjes in the north of our country has, from 1913 to 1918, made several experiments on soil infec-

tion and never saw traces of it, either in the plants of the experiment or in their progeny. The number of intervening winters during the term of his experiments varied from two to five. Wortley (1918) agrees with Oortwyn Botjes in this respect. The following circumstance is to be considered in explaining the positive result of 1915. It is observed that in Wageningen, in mild winters, some deep grown tubers often remain alive in the soil, from which stunted plants develop, which, even when the field is regularly cultivated, may again produce some deep growing little tubers. As shown in figure 11, tubers are found also at a depth of about half a yard in the soil, which, after having passed the first winter, produce no stalks but only tuber-bearing stolons (cf. also Vochting, 1902). That the contagium lives as a saprophyte in the soil is not probable; it seems to depend upon living parts of the plant. It is scarcely to be supposed that the contagium could keep in this way for more than two winters. The observations of Oortwyn Botjes (1919) give occasion to

FIG. 11. DEEPLY BURIED POTATOES, SHOWING TUBER FORMATION WITHOUT FOLIAGE

the suggestion that some of the infections ascribed by the writer to the soil in reality originate from diseased plants which were growing at a distance of about twenty yards from his experimental plots.

In experiments on soil infection with mosaic negative results were obtained in 1917-1918.

As the contamination of neighboring plants in the case of both diseases passes through the soil and the growing together into an organic union of the tissues of the roots is not known to occur, it would seem that the contagium lives for some time in the soil until it is taken by the roots. It is a matter of doubt whether wounds are essential for the catching of the infection.

Tobacco mosaic is identical with or at least closely related to potato mosaic. Tops of mosaic potato plants have been grafted on healthy tomato and tobacco, so have tops of mosaic tomato on healthy potato and tobacco, and tops of mosaic tobacco on healthy potato and tomato. It was stated that the disease always proceeded from tobacco to tomato and reciprocally in about two weeks. Spreading from tobacco to potato

or vice versa has not yet been observed by the author, but positive results were obtained in the grafting of tomato on potato of the variety "Zeeuwsche Blauwe" and back to tomato. With two other potato varieties, Eigenheimer and Bravo, no interchange occurred. So this question has as yet been only partially solved. It would seem that the contagium of tobacco has more difficulty in adapting itself to potato than to other Solanaceae, and a wide field opens here for experiments on adaptation. At all events, it is clear now that the name mosaic is to be preferred for the potato disease and that the term "curl" has only an historical value.

In the case of potato leaf-roll and mosaic there is some irregularity in the infection of neighboring plants, some of them giving a progeny which consists partly of typically diseased and partly of healthy plants. Also in primarily infected plants, and even in secondarily leaf-rolled plants, not all sieve strands are attacked. This would make us consider the contagium rather as a parasite than as a fluid. The same consideration holds good for the infectious mosaic of ornamental Abutilons and other Malvaceae. When this beautiful variegation is propagated by grafting on the perennial Malvaceous plant *Sida napeae*, some of the shoots will show the symptoms of mosaic next year, whereas others are exempt from it (Lindemuth, 1907). Phloem-necrosis of coffee (Stahel, 1917), yellow-stripe and sereh of sugar cane in Java, which also have been considered as degeneration diseases, mosaic of beet (Lind, 1915), peach yellows and rosette (E. F. Smith, 1891), the spike disease of sandal (Leslie C. Coleman, Mysore, Bangalore), and the Japanese mulberry disease resemble very much the potato diseases described here. Schizo Miyake of the Imperial Agricultural Institute, Nakano, Japan, will soon publish his investigations, from which it will be clear that this mulberry disease is related to leaf-roll with respect to the phloem being attacked and to infectiousness.

Only the new leaves and axillary shoots are able to assume the symptoms of mosaic and related diseases; in other words the contagium once introduced into the plant is directed with the flow of organic material to the nascent tissues. The fact that this flow passes through the phloem strands is most conspicuous in the case of phloem-necrosis, where the conducting tissues themselves have been attacked already. How the transport of starch from the leaves downward is prohibited by the phloem-necrosis is shown in figures 12, 13, and 14,[1] which give sketches of healthy and diseased plants that were submitted in the very early morning to

[1] Quanjer, H. M. Sur la fonction du tissu criblé. *In* Meded. Wageningen. Landbouwhoogeschool, **16**: 95–104, fig. 3, 4, and 5. 1919.

Sach's reaction with iodine. Healthy plants have conveyed all their carbohydrates to the tubers, but the lower leaves of the secondary diseased ones are still full of starch. In this type of plant phloem-necrosis proceeds from the base upward as the external symptoms do and likewise the stoppage in the translocation of starch is most efficacious in the basal leaves. In the primarily diseased plants a little phloem-necrosis is found in the upper part of the stalk and the upper leaves. Here the starch translocation is inhibited, whereas the lower leaves are empty. The

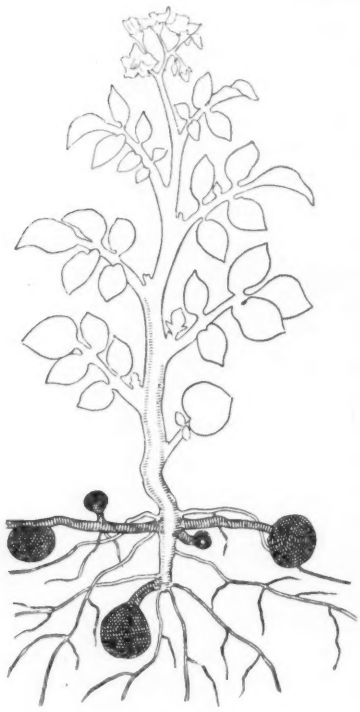

FIG. 12

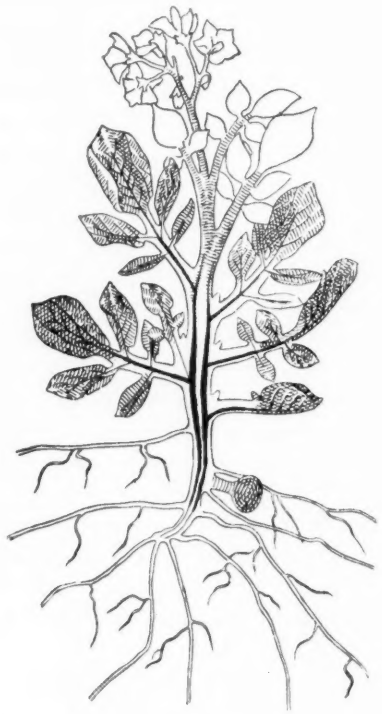

FIG. 13

FIG. 12. DISTRIBUTION OF STARCH IN THE EARLY MORNING IN HEALTY POTATO PLANT

It is to be met with only in the tubers

FIG. 13. SIMILAR EXPERIMENT IN A PLANT WITH SECONDARY LEAF-ROLL

The necrosis of the phloem strands, as pointed out by the black lines in the stalk, is most intense at the base. Here the translocation of the starch has almost entirely come to a stop, as can be shown by means of the iodine reaction of Sachs, and is indicated in the drawing by a black shading.

stalk, because of the delay in the transport, has not been able to convey all its starch to the tubers.

In physiology, the old dispute between Hanstein (1860), who supposes the carbohydrates to pass through the phloem strands, and Sachs (1863), who supposes them to pass through the parenchyma, has never been settled. The author's observations are strongly in favor of Hanstein. Only the fact that the transport of starch from the light colored parts of the leaves of mosaic potato and tobacco plants is delayed, even without phloem-necrosis being present, gives rise to the suggestion that some enzymatic disturbance may also take part in the slackened translocation of organic food. But the tardiness in the translocation of starch in the diseased areas of mosaic leaves is much less than in the leaves of plants suffering from phloem-necrosis.

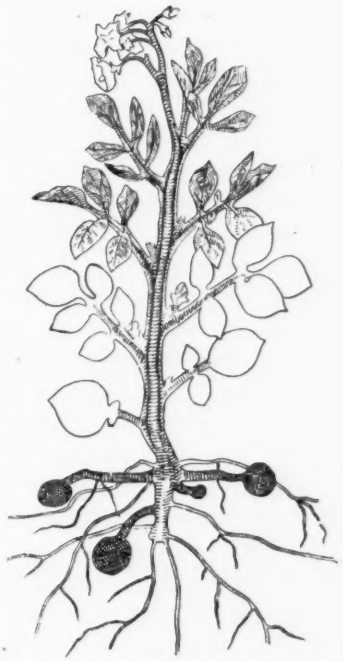

FIG. 14. THE SAME EXPERIMENT IN A PLANT WITH PRIMARY LEAF-ROLL

The necrosis of the sieve tubes starts in the top and here only is the downflow of carbohydrates restricted. The stalk, because of this delay, has not been able to convey all its starch to the tubers.

Whereas the transmission of either phloem-necrosis or mosaic to the progeny of diseased potato plants by the tubers takes place without an exception, the transmission by way of the embryo is rather rare; in the case of tomato mosaic it sometimes occurs; in the case of tobacco mosaic it is not known to occur. Allard wonders what efficient barrier may guard the embryo. When we suppose the cause to be a parasite, be it an ultramicroscopic one, it is easy to understand that the embryo is protected from infection. The phloem strands connect the mother plant with the young tuber, but between the plant and the embryo this connection is interrupted twice, once between the mother plant and the endosperm and the second time between the endosperm and the embryo. The embryo feeds by means of osmosis and can only absorb fluid matter. So there is every reason to agree with Allard (1915) that the pathogenic agent is a parasite. That bacteriology has not succeeded in cultivating the organism is no proof that there is no organism present.

The well known hypothesis of senility of potato varieties as a consequence of vegetative reproduction is explained by the fact that the two diseases which have been considered as degeneration are always propagated by the tubers and exceptionally by sexual reproduction. This hypothesis has been supported also by the fact that plants attacked by phloem-necrosis or mosaic are more susceptible to *Phytophthora infestans* than healthy potato plants of the same variety. There may be yet another reason for the degeneration theory, as the possibility must be admitted that the contagia which cause phloem-necrosis and mosaic will gradually adapt themselves to varieties which at first were highly resistant.

True leaf-roll or phloem-necrosis seems to be prevalent in all countries where the culture of potatoes has some importance. Until recently no data being at hand about its occurrence in France, the author asked Foëx (Paris) to inquire into the matter, and was soon informed (1914) that it prevailed severely in that country. V. D. Goot (Buitenzorg) sent some samples with typical phloem-necrosis from Java, where potato culture is practiced on the highlands. Since its relation with the tobacco mosaic has been shown, the potato mosaic also must be widely spread.

Oortwyn Botjes has shown how from susceptible varieties disease-free (not immune) strains can be isolated; the same method has been applied in getting rid of mosaic. By means of selection, satisfactory results have been obtained in the province of Frisia in maintaining the well known Frisian Eigenheimer, which is susceptible to mosaic. This selection is greatly promoted by the well organized field inspection service in that province. At the commencement of this organization (about 1903) only a very crude selection was made by removing diseased "hills," but gradually some farmers have systematically selected the best plants and from each of them they bred the progeny apart, selecting from it anew the best plant, and so on. Some farmers have had the good fortune to avoid the sources of infection without knowing mosaic to be contagious. But now that they have been informed about the mode of dissemination of this trouble they are more able to avoid reinfection.

One of the most important points in the breeding of new varieties from the true seed must be to pay close attention to their resistance to mosaic and phloem-necrosis. The variation in the asexual reproduction is much more limited than in the sexual one; whether it is possible to obtain resistant strains exclusively by selection is doubtful. Only when sports (mutations) occur, it seems that deviations in susceptibility may be connected with differences in shape and color of the tubers and growth habit of the "vine." This part of the problem is still in its infancy.

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RAISING PHLOEM-NECROSIS AND MOSAIC FREE POTATOES, AND A SOURCE OF INFECTION WHOSE NATURE HAS NOT YET BEEN ELUCIDATED

J. Oortwyn Botjes

Phloem-necrosis and mosaic in potatoes will pass from diseased plants to neighboring healthy ones. In the majority of cases the infection is not observable during the period of growth, but becomes apparent in the progeny, the more so as the distance between the healthy plant and the diseased one has been smaller. On sandy soil that was rich in humus, infection has taken place at 2 meters distance, and it is probable that under certain circumstances it may exceed this limit.

The above method of infection is the only one that has been demonstrated with absolute certainty to play a great part. It is true that after mild winters the disease has been detected in healthy potatoes that had been grown immediately following a diseased crop, but in this case the infection may have proceeded from volunteers or from growing tubers remaining alive in the soil and forming only secondary tubers.

In my own experiments, where one or two years intervened between the two crops, there never was any influence from a preceding diseased crop to be detected, so that it may not be of great practical importance, though its possibility must be taken into account.

Still, while excluding every possibility of infection through neighboring plants or prior cultures, infections of the phloem-necrosis and mosaic were pointed out in my fields in the year 1917. The appearance of these momentary infections can not be explained, but perhaps they must be accounted for by the influence of diseased plants growing at 20 meters distance if not more. Quanjer found a close relation to exist between potato and tobacco mosaic. Since this last disease is spread by aphids, it is possible that these or other insects act as disease carriers in the cases in which spreading has occurred. It is not impossible that plant lice are responsible for the greater spreading power these diseases seem to have on Long Island than in Maine. Therefore, in raising disease-free seed potatoes one should bear in mind that diseased plants are sure to infect their sound neighbors and that infection may be due to a diseased preceding crop, or the presence of diseased plants at a considerable distance.

In the raising of seed potatoes one must begin with healthy plants, which is difficult because in most cases it is not possible to detect primary infection, though secondary infection may be easily found out. Therefore, in selecting the plants reserved for seed, one should not only reckon with their outward appearance, but also with the relative possibility of their being infected. Such plants are to be selected as grow at more than 2 meters distance from diseased ones and in a field where the diseases if present are not severe. Not all the selected plants are likely to prove healthy. Some are sure to produce sick progeny that will infect the others if growing too near. Therefore the tubers of each selected plant should be planted in a row and the rows should be arranged so as to leave a space of at the least 3 or 4 meters distance between them. The space between the potatoes in each row may be 50 cm. if they proceed from the same plant; if not, a space of 3 to 4 meters should be kept. Intervening spaces may be planted with beans, beets, cabbage, or other low growth. The crop should be closely watched throughout the year, and every irregularity should be noted on a ground plan. If some of the progeny of one plant should produce sick plants, all the others proceeding from the same plant should be rejected. It is advisable to remove the sick plants as soon as possible, in order to preclude "infection at a great distance."

For culture only such potatoes are used as proceed from plants that have produced an entirely sound progeny. Some of them are set aside to be planted next year on a nursery plot in the above mentioned way, whereas the others are planted on a reserved field for the increase of planting material.

Nursery plots, as well as reserved fields, should be kept at as great a distance as possible from other potato fields; they must not be manured with stable dung, which might contain potato rubbish, and must have been free from potato culture during the last two or three years.

When hoeing the fields or when lifting the potatoes, care should be taken that no earth is transported from sick plants to healthy ones. The above method of raising disease-free seed potatoes may be applied both in case of phloem-necrosis and of mosaic. With both diseases the infection occurs in the same way.

OOSTWOLD, OLDAMBT
HOLLAND

PHYTOPATHOLOGICAL NOTES

Phytophthora cactorum (*Leb. et Cohn.*) *Schroeter.* This interesting fungus was found in September, 1919, attacking the fruits of a pear tree at Kentville, Nova Scotia.

H. T. Güssow.

Personals. Dr. Carl Hartley, formerly pathologist in the Office of Forest Pathology Investigations, Bureau of Plant Industry, has resigned to take a position in the Institute for Plant Diseases at Buitenzorg, Java. Dr. R. D. Rands, formerly of the Office of Cereal Investigations of the same Bureau, who went to the Institute at Buitenzorg in 1918, has been engaged there in the study of the brown bast disease of rubber. Two Swiss botanists, Doctor Gäumann and Doctor Paravicini, passed through the United States some months ago on their way to accept positions in the same institution.

Dr. W. H. Rankin, for five years assistant professor of plant pathology in the New York State College of Agriculture at Cornell University, has been appointed officer in charge, Field Laboratory of Plant Pathology, St. Catherines, Ontario, in the Canadian Department of Agriculture, and has entered upon his duties.

Mr. Emery D. Eddy, who has been engaged during the past year in the investigation of diseases of market vegetables, for the Department of Agriculture, recently resigned his position to take up commercial work.

ABSTRACTS OF PAPERS PRESENTED AT THE ELEVENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, ST. LOUIS, DECEMBER 30, 1919, TO JANUARY 1, 1920.

Recent studies on Septoria of wheat. RICHARD O. CROMWELL

Septoria of wheat in the imperfect stage survives the period from harvest time until the rosette stage of winter wheat. Pycnospores retained vitality on leaves of the 1919 crop until early in October. Mature pycnidia were found on volunteer and winter wheat seedlings as early as October 2 and November 1, respectively. Spores were viable on November 10, the date of last test. Artificial infection was secured with spores from the 1919 crop and later from volunteer plants. The maximum and optimum temperatures for germination of pycnospores are 34, and 24 to 28°C., respectively. The time for germination varies between twenty-five and twenty-four hours, depending upon the stage of maturity and certain other factors.

Septoria was most readily isolated by using material which had a large percentage of the spores in condition for rapid germination and growth. On potato agar the young growth is disciform, mucose, and pink to lilac; later it is restricted, mucose to waxy, and pink to dark gray. During the first thirty days mycelia are meager, and spore-like (pionnotes-like) bodies abundant. These bodies, resembling pycnospores in size, form, and septation, function in producing artificial infection. Old cultures are composed entirely of short, swollen, chlamydospore-like cells. On sterilized wheat straw pycnidia become visible in eight days.

An epidemic of Fusarium blight (scab) of wheat and other cereals. A. G. JOHNSON, JAMES G. DICKSON, and HELEN JOHANN

An unusually severe epidemic of Fusarium blight or scab occurred on both winter and spring wheat during the past season. Rye, oats, and barley were also attacked. The disease was particularly severe in the Mississippi Valley and eastward. The winter wheat throughout this area was universally attacked, infection ranging from a trace to fifty per cent. The spring wheat, particularly where planted in the winter-wheat area, was infected unusually heavily. In numerous cases large fields of Marquis wheat were left unharvested because so badly blighted.

An extensive survey over fifteen states, correlated with an intensive survey over nine states in the winter-wheat area, brought out some pertinent facts with reference to the epidemic. A careful study of over one thousand specimens collected in the fifteen states showed *Gibberella saubinetii* (Mont.) Sacc. to be the chief causal organism. Less than 1 per cent of the specimens yielded *Fusarium culmorum* (W. Sm.) Sacc., *F. avenaecium* (Fr.) Sacc., and other Fusarium species. The highest infections occurred where wheat followed corn or wheat in the rotations, or where old grass refuse had been allowed to accumulate in fence rows and field margins. The abundant presence of the parasites and the moist, warm weather following the blossoming period of the grain favored development of the disease. Detailed investigational work is in progress on various phases of the problem, including control measures.

The effect of temperature and light on Fusarium sp. causing wheat scab. JEAN MACINNES

An investigation was made of the effect of temperature and light on the species of Fusarium commonly causing wheat scab in Minnesota. Repeated trials show that the minimum temperature for growth is approximately 5°C., the optimum near 25°C., and the maximum between 30 and 35°C. Field experiments showed that a greater percentage of wheat heads became scabby when the temperature at the time of their emergence from the sheath was about 76°F. (24.4°C.) than when the temperature was lower. Apparently high humidity is conducive to the development of the disease.

Both diffuse light and sunlight injured the viability of spores. Only about 1 per cent of the spores from scabby heads which were exposed all winter to light either outside or indoors germinated in the spring, while the spores from heads which had been kept in the dark germinated readily. The average percentage of germination of spores kept in the dark outside was nearly twice as great as that of those kept in the dark inside.

Foot-rot of wheat and its fungous associates. F. L. STEVENS

Foot-rot of wheat as found in Madison County, Illinois, is described in general and histologically and the more significant fungi associated with this disease are discussed.

The resistance shown by three hard winter wheats, Kanred (P762), P1066, and P1068 to plant diseases. L. E. MELCHERS

Various publications by J. H. Parker and the writer have called attention to the resistance of these wheats, products of the Kansas Experiment Station, to stem rust (*Puccinia graminis tritici*). Their use as differential hosts for physiological testing of rust strains is quite outstanding. Unpublished data conclusively show that they are resistant to leaf rust in Kansas. No statements are ventured as to whether the leaf-rust infection during six years observations was caused by one or more biologic strains. The field behavior of Kanred throughout Kansas the past season to the leaf and stem-rust epidemic was striking. This is especially interesting because of the great commercial value of Kanred.

C. E. Owens, of Oregon, states that in an induced epidemic of stripe rust, 1919, these varieties remained free of rust at all times. Their resistance to stripe rust in the field and greenhouse, however, has not been constant. E. C. Stakman has stated that all three varieties are only slightly susceptible to *Puccinia graminis tritici-compacti*. This marked resistance is not maintained, however, for all biologic forms of stem rust. F. D. Heald has unpublished data which show that Kanred shows resistance to stinking smut of wheat when compared with other commercial varieties. Kanred is also showing resistance to other diseases in varietal tests, but specific mention of these is being withheld for the present.

The resistance of Kanred (P762), P1066, and P1068, three hard winter wheats, to leaf rust. LEO E. MELCHERS AND JOHN H. PARKER

Careful observations the past six years have shown that these varieties are markedly resistant to leaf rust under Kansas conditions. The average percentages of leaf rust for these seasons were consistently low, 9.5 per cent in the case of Kanred (C. I. 5146), 6.2 per cent for P1066 (C. I. 5879), and 5.7 per cent for P1068 (C. I. 5880). Leaf rust as it occurs in Kansas, however, may or may not show the same biologic specialization as the leaf rust occurring in other regions.

A severe epidemic occurred in the state the past season, some wheat fields being plowed up because they were so severely injured. Approximately 50,000 acres of Kanred were grown in 1919. About eight hundred fields, belonging to 572 growers, were inspected, these fields being located in forty-six counties in different parts of the state. The percentages of leaf-rust infection in all these Kanred fields were strikingly uniform, ranging from 8 to 10 per cent. Adjoining fields of Turkey and Kharkov, commonly grown varieties, showed from 20 to 100 per cent leaf rust, the majority approaching the latter figure. The varieties P1066 and P1068 are not being grown commercially, but showed even more resistance than Kanred at the Experiment Station.

The development of loose smut of wheat as modified by soil fertility. F. D. FROMME.

In a series of field plots subjected to continuous wheat cropping with varying applications of fertilizers, the percentage of heads affected with loose smut (*Ustilago tritici*) varied according to the degree of soil fertility maintained. The highest percentages of smut are found in plots of low fertility, and vice versa. Similar observations were made in connection with stinking smut (*Tilletia laevis*) in greenhouse plots. It seems probable that these variations are due to the total or partial elimination of the smut fungus by the greater vigor of the growth of the plants on the more fertile soils.

Relation between soil moisture and bunt infection in wheat. CHAS. W. HUNGERFORD AND A. E. WADE

Field observations during the last four years in Lewis County, Idaho, which is in the area where soil infestation by bunt is common, have shown a close relation between the amount of bunt on winter wheat and the amount of moisture in the soil at the time of planting. Observations have been made in a number of fields of wheat where seed from the same lot was sown before and after a rain. Only a small amount of bunt was found in the portions of the fields sown in rather dry soil, which contained, in most cases, close to the minimum amount of moisture necessary for good germination of the seed. On these fields those portions sown after it had rained contained in some cases over 30 per cent of bunt.

During the past summer the following experiment was carried on both on the Experimental Farm of the Agricultural College at Moscow, Idaho, and at Nezperce, in Lewis County, Idaho. Six large soil containers were filled with soil containing different amounts of moisture varying from saturation to less than enough to cause good germination of the seed. The soil was heavily smutted and the seed was covered with viable spores of *Tilletia tritici*.

The following table gives the results of the tests:

At Nezperce, Idaho		*At Moscow, Idaho*	
Soil Moisture	*Smut per cent*	*Soil Moisture*	*Smut per cent*
7.7	0	7	No growth
15	7	12	0
20	26	17	25
24	27	21	30
36	62	25	68
38	No growth	38	100

This work is being repeated in both greenhouse and field and under more accurately controlled conditions.

Experiments on the control of stinking smut of wheat. G. H. COONS

Samples of wheat of seventeen varieties, heavily dusted with *Tilletia laevis* and *Tilletia tritici*, respectively, in September, 1917, were planted in 1918, and gave in 1919 yields free from any trace of *Tilletia tritici*, but with abundant *Tilletia laevis* infection. Striking differences in the amount of smut due to *Tilletia laevis* were evident in the series, certain wheats, such as Little Club and Zimmerman, showing 60 per cent or more of smut, while Turkey P889, Turkey P1038, Nebraska Hybrid, and Fultz showed 4, 4, 2, and 0 per cent respectively. In many cases the stand was sharply reduced in the smutted series, the reduction being greatest in those varieties showing most smut.

Best smut control was obtained with heavily smutted Red Rock wheat by the "soak and skim" method, using 1 pint of formaldehyde to 40 gallons of water, no trace of smut appearing in the plots. In sprinkling experiments, using the same solution, if the grain was sprinkled until wet and covered four hours, control was perfect. With less time of covering or with only 1 quart of solution to the bushel control of smut was poor.

The "dry" treatment, using 1 pint of formaldehyde plus 1 pint of water to 50 bushels of grain, gave perfect control. Lesser amounts of formaldehyde and greater dilution with water gave poorer smut control.

Slight injury to stand seems incident to any formaldehyde treatment, but unless covering is long or strength of solution excessive this effect is compensated by the growth of stalks. The utilization of a follow-up spray or dip of ammonia to neutralize the formaldehyde by the formation of Hexamethylene tetramine is suggested.

Evidence of disease resistance in barley to attacks of Rhynchosporium. A. G. JOHNSON and W. W. MACKIE

The disease of barley and rye caused by *Rhynchosporium secalis* (Heinsen) Davis has been noted in limited amounts in the upper Mississippi Valley for a number of years. In this section the attacks have been, on the whole, rather scattered and only occasionally severe. In certain sections on the Pacific coast, especially in California, this disease has been more severe, particularly on barley. Differences in susceptibility of various barley varieties have been previously noted by others. During the summer of 1919 the writers, in examining a large series of barley varieties growing at Davis, California, noted what seemed to be evidence of disease resistance in only two varieties in the entire series, all others being heavily attacked. These were three different selections of Tennessee Winter and one selection of Mariout. Other selections from these same varieties grown in adjacent rows in the same series of plots were heavily attacked, as were all the other varieties.

The purple sheath spot of corn. L. W. DURRELL

Corn is universally affected by a disease producing purple blotches and spots on the leaf sheaths. This was early attributed by Burrill to bacteria, which in the first part of the season also caused a dwarfing of certain plants in the field. The spots are external manifestations of necrosis of the tissues on the inside of the sheath. They appear only after the fall of the pollen and late in the season are present on practically every corn stalk.

Over the diseased areas within the sheaths are to be found great numbers of dead pollen grains and pollen sacs that have worked past the ligule and into the moist enclosure of the sheath. These pollen grains and sacs act as media for saprophytic organisms, which later enter the sheath tissues. Sugary secretions of aphis may act

in a similar way. The exclusion of pollen and aphids from the leaf sheaths has been found to eliminate the spot. On the other hand the introduction of pollen or pollen sacs exposed to spores of various molds and other fungi produces the spot. The introduction of mycelium or spores of these fungi however has no effect unless accompanied by a small bit of agar. Sections of sheath spots show stomatal invasion by fungi and bacteria, prior to necrosis of the tissues.

Some results of corn root rot work in Ohio. W. G. STOVER

In coöperation with farmers in several counties, seed corn was tested for germination, each lot being divided into several groups and planted on the farms. In September no difference could be seen between the various groups except in one instance. In this case the group planted from ears which showed Fusarium-like fungi in the germinator was much poorer than the others. In several cases an application of manure or nitrate of soda resulted in a great improvement in the appearance of the corn in all the groups.

Two hundred and eleven ears were tested a second time and planted in separate rows. The average yield of the rows planted from ears free of Fusarium-like fungi exceeded the others at the rate of more than 4 bushels per acre. Data were also collected on the relative numbers of ears, nubbins, and barren stalks in these rows. There was a marked variation in the results of the two germination tests.

Corn root and stalk rots. J. R. HOLBERT AND G. N. HOFFER

Corn generally is more or less affected by root and stalk rots. In the principal corn growing sections the losses resulting from these diseases range from traces to 25 per cent and more. The symptoms so closely resemble and are so intimately related to the effects of drought, low fertility of soil, poor drainage, insect and frost injuries that their diagnosis is sometimes difficult. Probably the greatest loss due to these rots is caused by using infected seed. Many kernels from badly infected seed ears either do not germinate or produce seedlings that die before reaching the surface of the soil or soon afterwards. Other infected kernels produce chlorotic and blighted seedlings and stunted stalks. This early retardation of growth of infected seedlings is responsible for much barrenness and many nubbins. Badly infected kernels and seedlings may cause a secondary rotting of the roots of other seedlings and plants in the same hill. Corn that is planted in infected soil may become infected later in the season. These secondary infections also cause a retarded growth and subsequent barrenness and nubbin production. Other symptoms resulting from secondary infections are leaning and down stalks, broken stalks, broken shanks, wilted plants, and prematurely dead plants. Secondary infections may cause barrenness, due to the abortion of the reproductive parts. Ears borne on infected plants are usually more starchy in composition than ears borne on healthy plants. Such ears are unsatisfactory for seed purposes.

The pathogenes are chiefly species of Fusarium and Gibberella. The common wheat scab organism, *Gibberella saubinetii* (Mont.) Sacc., is probably the most common pathogene responsible for much of the root and stalk rotting of corn plants in the Central States.

The most successful control measure that has been developed so far is the selection of seed from healthy, vigorous plants that show no evidence of disease upon germination, culling out by physical selection those ear types that have been found to be more susceptible to these troubles. Breeding experiments are being conducted to develop resistant strains and varieties.

I Iron accumulation and mobility in diseased cornstalks. G. N. HOFFER AND R. H. CARR

The internal tissues of each node in a corn stalk can be differentiated into two zones, the upper, Zone A, functioning in starch accumulation and the growth of the internodes, and the lower, Zone B, where the fibrovascular bundles branch to form the bundles extending into the roots, leaves, and husks of the ears.

Iron and other metallic bases accumulate in organic combinations in the Zone B tissues, first in the phloem cells, and later in the walls and lumina of the zylem elements. The central bundles of the lowest nodal tissues in the stalks are the first to accumulate iron compounds in greatest quantities. The amounts which accumulate seem to be directly related to the premature dying of the lowest leaves. This phenomenon is commonly referred to as "firing."

When the corn stalk show the effects of malnutrition and the symptoms of root rot infections, the Zone B tissues are frequently brown to brownish-purple discolored. Iron compounds are invariably present in larger quantities, as determined by chemical analyses, and oxidase and catalase activities are greater in the nodes of infected stalks than in those of normal healthy stalks of the same age in the same soil. Aluminum and manganese compounds have also been found in greater quantities.

The H-ion concentration in the Zone B tissues approaches neutrality (pH = 6.2-6.8) in the stalks showing the disease symptoms of root rots, whereas in the normal stalks the concentrations approximate those of the internodal tissues (pH = 4.0-5.2).

By testing stalks showing various symptoms of malnutrition and infection by root- and stalk-rot organisms, it was found that water, colored slightly with methylene blue, was not conducted in the vessels in the nodes which showed the largest accumulations of iron in them. Healthy stalks would always have practically all of the vessels functioning. Cross sections of the bundles in the Zone B tissues of healthy and diseased stalks show varying quantities of iron compound deposits in them, the greater quantities appearing in the bundles of diseased stalks.

It is believed that the metallic bases, with special reference to iron, are responsible for causing changes in the normal functioning of the Zone B tissues, first, in the translocation of carbohydrates from the leaves to the stem and roots by the phloem elements, and later in the conduction of water and mineral nutrients in the transpiration current.

If iron compounds are present in seedlings in supra-optimal quantities they will be noticed first in the lowest Zone B tissues, which are located at the distal end of the mesocotyl. When this accumulation occurs very early in the life of the young plant it is associated with a retarded growth of the plant.

Corn plants with the upper leaves chlorotic are characterized by low H-ion concentrations and contain immobile iron compounds within them. The Zone B tissues at the bases of the chlorotic leaves give no reaction for the presence of iron, whereas in the lower tissues iron compounds can be found. No tendency toward chlorosis was found in any of the stalks which had a relatively uniform H-ion concentration of pH = 4.0-5.0 in the Zone B tissues. The rates of growth of young plants and the degree of chlorosis may be determined by the relative abilities of the plants to develop and maintain a sufficiently high H-ion concentration to keep the iron compounds mobile as occurs in normal green plants.

II. Experiments to test effects of iron salts on corn plants. G. N. HOFFER AND R. H. CARR

In order to test the capacity of the Zone B tissues of healthy corn stalks in the field to accumulate iron and other metallic base compounds, 0.5 per cent, 1 per cent, and 2 per cent solutions of iron sulphate, iron chloride, iron citrate, iron carbonate, iron nitrate, dialyzed iron, copper sulphate, aluminum chloride, and aluminum sulphate were used. Punctures were made in the internodal cortical tissues just above the upper nodes bearing roots. The solution were introduced through glass tubes inserted in the stalks.

The ferrous sulphate solutions were very active in affecting the Zone B nodal tissues. Catalase and oxidase actions were greatly increased. The tissues became brown and disintegrated, the leaves wilted and fired, and premature death of the stalks resulted. The nodal tissues were heavily laden with iron compounds and presented an appearance similar to those of infected stalks. Approximately 25 cc. of a 0.5 per cent solution introduced into healthy stalks 6 to 8 feet high proved effective. The effects of the treatments were similar to those observed in stalks affected by root rots.

The ferric salts of equal concentrations and quantities were either less effective or had no apparent effects whatever. Ferric citrate, however, in a 2 per cent solution darkened the bundles and caused a wilting of the leaves. In all cases the ferric salts stimulated oxidase and catalase action, but not to the same degree as the ferrous sulphate solutions. Potassium sulphate in a 2 per cent solution had no noticeable effect in the same period of time. Dialyzed iron was not appreciably absorbed.

Aluminum salts in equivalent concentrations also stimulated catalase and oxidase action in the Zone B tissues. Copper sulphate in a hundredth normal solution was very toxic, both the Zone A and Zone B tissues of the nodes were destroyed. The copper compounds could be detected in quantities in both sets of tissues.

Check plants supplied with water or with nutritive salt solution in equivalent concentrations showed no harmful effects from the treatment.

Correlation of early growth, variation and productivity of maize as influenced by certain pathologic factors. J. R. HOLBERT, JAMES G. DICKSON, AND H. HOWARD BIGGAR

Inoculation experiments were conducted during the season with Funk's Ninety Day corn selected from apparently healthy plants and diseased plants. The ears differed in their disease reading on the germinator. They were used in ear-to-row plots on soil that had not grown corn for the previous twelve years. In each row alternate hills were inoculated at planting time with *Gibberella saubinetii* (Mont.) Sacc. from wheat. In the inoculated hills germination was lowered, early growth retarded, relative vigor through the season reduced, storm resistance decreased, and average grain production lessened. The plants in the uninoculated hills planted with apparently disease-free seed from healthy plants remained normal. *G. saubinetii* was readily recovered from the diseased plants in the inoculated hills, especially during the seedling period.

Plants, strong or weak in the early stages of growth, had a tendency to retain this relative vigor throughout the season. Average grain production was directly correlated with rate of early growth and early vigor. Seed selected from prematurely ripe plants, but showing no evidence of disease on the germinator, lacked the ability to compete successfully with the disease-free seed selected from plants maturing normally. Apparently disease-free germinating ears selected from

healthy, vigorous plants produced plants that had a more rapid early growth, more storm resistance throughout the season, and a higher average grain production than diseased germinating ears similarly selected.

Apple blister canker. W. O. GLOYER

The following conclusions have been reached after seven years' study of the blister canker: (1) The canker caused by *Nummularia discreta* Tul. is not as important economically in New York as in the middle west. (2) The fungus is more actively parasitic on Sorbus than on Malus. (3) Forms varying in pathogenicity and cultural characters sufficiently to be called varieties or strains are produced by varying the substratum upon which the parasite grows. (4) It may be active in the wood and yet show but little canker formation. (5) The presence of the fungus in the wood is one cause of slime flux. (6) Cankers may enlarge at any time between early spring and late autumn. They enlarge slowly during periods of drought and become more active after rains following a drought. (7) Shellac followed by coal tar was found to be the most satisfactory covering for pruning wounds. (8) The covering is not the controlling factor in the healing of a cankered wound. (9) The physiological condition of the host determines the activity of the parasite. (10) Parasitism is complex and can not be measured in terms of percentage of water content of the wood as indicated by Münch.

A preliminary report on apple scab and its control in Wisconsin. G. W. KEITT

During the past season, the discharge of ascospores of *Venturia inaequalis* (Cke.) Wint. was carefully followed at Madison and at Sturgeon Bay. At Madison it began on April 20 and ended about June 7. The heaviest discharges occurred prior to May 8. The blossom buds did not separate in the clusters until about May 14–18, the time varying with varieties.

At Sturgeon Bay the first ascospore discharge was noted on May 15, and the last on June 16. The heaviest discharges occurred prior to May 23. The blossom buds did not separate in the clusters until about May 26–30.

At Sturgeon Bay on certain badly scabbing varieties, lime-sulphur and Bordeaux mixture failed to control scab satisfactorily when applied comparatively according to the standard four-spray schedule: (a) May 26–27, as soon as the blossom buds separated before blooming; (b) June 4–5, when three-fourths of the petals were off; (c) June 18–19; and (d) August 20. The addition to this schedule of an application on May 16–17, soon after the blossom buds became exposed in the clusters, led to excellent control.

Results of spraying the apple for blotch in Ohio in 1919. W. G. STOVER, F. H. BEACH, AND T. H. PARKS

Spraying Clermont County orchards in 1918 at three weeks' intervals following petal fall gave less than 50 per cent marketable fruit. Three applications of Bordeaux mixture in 1919 in several counties at intervals of two weeks, followed by an additional application in July, gave an average of over 90 per cent marketable fruit. Unsprayed trees in the same orchards gave less than 10 per cent marketable fruit in the blotch areas. Sprayed trees bore more fruit and their apples were larger as a rule than those from unsprayed trees. No trees were sprayed on the three-weeks schedule in these trials.

A stem disease of tomato caused by Macrosporium solani E. & M. JOSEPH ROSENBAUM

A stem disease of tomato plants was found doing considerable damage the past season in Delaware. The disease has been found on all ages of plants. Affected stems, at the point where they emerge from the surface of the soil, are dark brown, shrivelling up with age, and a girdling effect is produced.

Numerous isolations and inoculations establish the fact that a fungus belonging to the genus Macrosporium is the causal organism.

Comparison of this Macrosporium were made with *M. solani* from potatoes and with Macrosporium cultures isolated from typical "nail head" spots on Florida tomatoes. These comparisons show that the Macrosporium discussed here is different from the one isolated from the "nail head" spots from Florida, in that the former is unable to produce infection on uninjured green fruit, as well as differing in culture and morphology. It resembles *M. solani* from potatoes in the kind of lesions produced when used for inoculation on fruit and stems, and in morphological characters. It should therefore be referred to as *Macrosporium solani* E. & M.

Field tests with strains of wilt-resistant tomato seed in 1919. J. A. MCCLINTOCK

Strains of seed from wilt resistant tomatoes from various sources were tested on a heavily infested piece of soil at the Georgia Experiment Station in 1919 and no strain proved sufficiently resistant to grow throughout the summer.

Strains of commercial peppers and eggplants grew and fruited throughout the summer on the same infested soil.

The Alternaria fruit rot and Rhizoctonia stem rot of tomatoes. MEL. T. COOK

This rot appears in three forms: (a) following the infection of cracked fruit, (b) following the infection of sun burned fruit, (c) nail head spot on green fruit. This papers refers especially to the second. Most of the sun burn is due to a loss of foliage following attacks of *Septoria lycopersici*. The fruit is most susceptible to sun burn just as it begins to color. The exposed surface becomes yellowish instead of red. This yellowish area begins to freckle with brown spots which enlarge, become black, rupture and show masses of spores. Cultures from youngest spots gave no growth but as the spots increase in age and size, it becomes easier to get growths.

The stem rot which was very prevalent in South Jersey in 1919 was due to Rhizoctonia attacking the stems at the surface of the ground. The disease evidently started in the seed bed but continued in the field causing heavy losses. This same condition was found in one field of cabbages.

Spacing tomato plants for field spraying. C. E. TEMPLE

It has been found from experiments extending over four years that the rows of tomato plants must be set approximately 6 feet apart in order to spray with large machinery without great loss from mechanical injury to the plants. On the other hand, the plants may be set close enough in the row to obtain the usual number per acre without loss from over-crowding. In Maryland the most desirable spacing for spraying purposes is three feet by six feet. Other advantages from this method of setting are: That cultivation may be continued later in the season than usual to conserve moisture, that a cover crop may be planted at any time without injury to the plants, that the plants interlock in the row so that they are not tossed about by the wind as much as when checked four or five feet each way, and that the crop may be harvested and hauled from the field without trampling the vines.

Tomato spraying experiments for the control of Septoria. C. E. TEMPLE

During the past four years an attempt has been made to devise a practical and effective method for controlling the Septoria leaf spot of tomatoes under field conditions. More than 200 acres of tomatoes were divided into plots and used in these tests. As a rule every third plot remained untreated as a check. On the other plots both liquid and dust sprays were used and these were applied in almost every case by traction or gasoline engine machines. A large number of spray formulas were tested, but the bluestone liquid sprays, both with and without rosin oil soap, were the most promising. These sprays were run in series to determine the most profitable number of applications to apply and also to determine the quantity of spray material to use. The formulas were applied at the rate of 50 gallons and 100 gallons per acre to determine the most economical quantity needed for the control of the disease. The results were variable, ranging from no increase in production in a few cases to more than 100 per cent increase in others. There was, however, usually a substantial increase over the checks wherever at least four applications of a Bordeaux or a Bordeaux soap were applied.

Effect of straw mulch on potato leaf roll. W. O. GLOYER

In 1918 plots of Sir Walter Raleigh potato on clay loam were covered with 3 inches of short straw while others were cultivated. When in bloom the leaf-roll plants were rogued and 267 hills in the mulch and 541 hills in the cultivated plots showed 11.6 and 11.4 per cent respectively. On the mulch plots the plants were of a yellower tinge, were killed earlier by frost, and had larger and flatter tubers than did the cultivated plants. The yield per plant averaged 630 grams in the former and 603 grams in the latter.

In 1919 the highest yielding hills from these plots were planted as units and given normal cultivation. The 197 hills from the mulch and 78 hills from the cultivated plots showed 59 and 28 per cent of leaf roll, respectively. In some units there was a tendency of the smaller tubers to produce disease-free plants. Conclusions:. (1) Mulching did not overcome the infectious nature of the disease; (2) in badly diseased fields even tubers of the healthy-appearing and high-yielding plants are unsafe for seed.

Sulfur experiments for the control of potato scab. WILLIAM H. MARTIN

Sulfur was broadcasted at the rate of 300, 400 and 600 pounds per acre just before planting. The 300 pound applications gave approximately as good results as the larger amounts. There was a marked increase in salable primes from the sulfur treatments.

Soil samples were taken at the start of the experiment and again when the crop was dug and the hydrogen ion concentration of the soil extracts determined colorimetrically. The samples examined before the sulfur applications were made were found to be slightly acid. An examination of the soil extracts from the different plots at the close of the experiment showed marked changes in hydrogen ion concentration. The untreated plots remained unchanged while there was an increase in acidity (decrease in exponent) where sulfur was applied at the rate of 300, 400 and 600 pounds per acre, the mean for the plots being 4.9, 4.9 and 4.5 respectively.

The 1919 survey for potato wart. G. R. LYMAN

During the past season the Plant Disease Survey, in coöperation with the Federal Horticultural Board, conducted an extensive survey in an effort to determine

the geographical distribution in the United States of potato wart, which was discovered in the autumn of 1918 in a large area in the neighborhood of Hazleton, Pa. Immense quantities of European potatoes, some of which may have been affected with wart, were imported before the imposition of the Federal Quarantine in 1912 and were distributed very widely. Hence the greater portion of the United States was under suspicion of harboring the disease, especially home gardens in cities and in other districts which are not in close touch with modern agricultural methods and workers. On account of the immense area to be covered in a short time with limited funds, the Plant Disease Survey endeavored to enlist the interest and assistance of as many helpers as possible. This effort was conspicuously successful and the survey was marked by the hearty and effective coöperation not only of the Survey's collaborators, but of growers and users of potatoes generally. Wart was found in small amounts in six villages in western Pennsylvania and in two villages in northern West Virginia, all being in the soft-coal section, except one of the West Virginia localities. Apparently no other extensive area of infestation exists at all comparable to the Hazleton district, but undoubtedly there are other undiscovered isolated points of infestation in regions out of touch with modern agriculturists. These can be brought to light only by further intensive survey.

Wood-destroying fungi in pulp and paper mill roofs. R. J. BLAIR

When the roof of a paper mill is built of wood moisture in the air permits the development of wood-destroying fungi in the timber. Rapid rotting takes place and it is often necessary to renew the timber after six or eight years' service. The roofs of eighty of the Canadian paper mills have been examined to find the different types of construction used and the services secured from each. The common faults in every case are that moisture enters the spaces between the planks and reaches their upper side, where it condenses, causing a moist condition of the planks during prolonged periods and at the same time the wood is of a non-durable species. There is no evidence that other species of fungi than three of those mentioned last year in connection with the cotton mill roofs, *Lentodium tigrinum*, *Lenzites trabeum*, and *Poria xantha*, cause these losses.

The remedy for such timber decay lies in a combination of four factors, which need consideration when the roof is being built. These are the use of wood which resists decay, ventilation which carries away the moisture, liberal dry-air heating, and a heat-insulating layer placed on the upper side of the planks.

Black crust of Brazil nuts. E. R. SPENCER

Brazil nuts are frequently affected by a fungus disease that is not noticeable until the nuts are shelled. The kernel is covered by a black mycelium, which destroys the outer cell layers.

On cornmeal agar the fungus grows well but slowly. A greenish black thallus, which produces very few, hairy, globose pycnidia after several weeks results from a direct planting.

The conidia are at first hyaline and single celled, but later become two celled and dark, with conspicuous striations. The spores are about 21 by 13 μ.

Leaf hoppers and hopperburn of potato leaves. J. E. KOTILA

During the summer of 1919 experiments were performed to ascertain whether or not tip burn of potato leaves was caused by leaf hoppers and to determine if aphids had a similar effect. Data obtained from these experiments are tabulated below.

Effect of leaf hoppers on potatoes

PLANTED	CAGED*	NUMBER OF CAGES	NUMBER OF PLANTS	TREATMENT	DATE	RESULTS	REMARKS
Field experiments, Upper Peninsula Experiment Station, Chatham, Michigan							
July 2	July 9	3	6	25 Leaf hoppers (Empoasca mali LeB, introduced into each cage	August 1	Burn	First sign of injury observed August 4. Leaves showed light-colored margins. August 14, margins of leaves brown. Serious burning in all 3 cages
July 2	July 9	3	6	Check. No insects	August 1	No burning	Leaves normal
July 2	July 9	1	2	25 Potato aphids introduced	September 4	No burning	September 25, leaves green
Greenhouse experiments, Michigan Agricultural College, with potted potato plants							
September 20†	At once	1	3	25 potato leaf hoppers introduced	September 22	Burn	October 1, leaves showed marginal injury
September 20†	At once	1	3	Check—no insects	September 22	No burning	October 1, leaves green

* Cages were set up July 9 before plants broke through soil and were of sufficient size to cover two hills. No insects on plants prior to date leaf hoppers or plant lice were introduced. † Sprouted tubers were potted on this date.

The results obtained from the above experiments are in accord with those obtained by Dr. E. D. Ball in 1918, report of which was published in Phytopathology, **9**: 291–293, July, 1919, and confirm his conclusions that the potato leaf hopper is responsible for the injury to potato leaves known to pathologists as "Tip Burn," but which he more aptly terms "Hopperburn."

The relation of soil temperature and soil moisture to the occurrence of cabbage yellows. W. B. TISDALE.

The results of greenhouse experiments with cabbage seedlings grown in "sick" soil held at constant temperature for twenty days show that yellows does not occur below 17°C. or above 34°, the optimum temperature being 25° to 28°C. This range compares favorably with the growth of the fungus (*Fusarium conglutinans*) in pure culture. Seedlings of the resistant cabbage strain, Wisconsin Hollander, are relatively susceptible until they are at least thirty days old. These results are supported by field trials on "sick" soil at Racine, Wis., during the seasons of 1917 and 1919. Continuous soil temperature records have been secured and correlated with the occurrence of the disease both in the regular field crops and in seedlings from successive plantings made at various intervals. The incubation period varies from one day at optimal temperature to sixteen days at 17°C., the time being reckoned from date the seedlings break through the soil surface.

Experiments were conducted with "sick" soil in which the moisture content was kept constant with Livingston's auto-irrigators and the temperature held at 20 to 22°C. The water holding capacity of the soil was 31.36 per cent figured on wet weight. The yellows occurs and develops most rapidly in soil with 19 per cent moisture, less rapidly with 26 per cent, and still less rapidly with 23 per cent moisture.

The influence of soil temperature on the development of potato scab. L. R. JONES AND H. H. MCKINNEY

Seasonal and regional variations have been observed in the occurrence of common scab on potatoes caused by *Actinomyces scabies* which seem to be correlated with climatic conditions. Opportunity has as yet permitted the investigation of the influence of temperature relations only. Evidence has, however, been secured that soil temperature is so important a factor that it may account for much variation. Greenhouse cultures with soil temperatures of 12°, 15°, 18°, 21°, 24°, 27°, and 30°C. have shown that the optimum for tuber development is about 18° to 21° while that for scab development is about 24°C. At higher temperatures the number of infections continues large but there is inhibition of tuber growth and associated size of lesions. In experimental field plots it has thus far been impossible to hold uniform soil temperatures. We have, however, by the use of mulches and cooling pipes with small plots secured data which is in essential accord with that from the greenhouse cultures.

The relation of soil temperature to the development of the tomato Fusarium wilt. E. E. CLAYTON

As a preliminary to the main work, the growth reactions of the fungus and normal plant was determined for a wide temperature range. Petri dish cultures of *F. lycopersici* were exposed to temperatures ranging from 8° to 38°C. for nine days. The optimum for growth was found to be about 28°C., the minimum 9° to 10°, and the maximum 37°. Very abundant growth, however, was secured at temperatures ranging all the way from 18° to 31°. The optimum soil temperature for the growth of the normal tomato plant was found to lie between 25° and 30°C., the maximum being a little above 35° and the minimum a little below 12°. Tomatoes grown in soil infected with pure cultures of *F. lycopersici* were subjected to soil temperatures ranging from 19° to 35°C., inclusive. The optimum soil temperature for the development of the disease proved to be about 28°C. The disease rarely appeared at

temperatures lower than 22° or higher than 32°. These trials were carried on at Madison, Wis., and the time of exposure to the different soil temperatures varied with the separate trials from four to six weeks during the late winter months, February–April.

Occurrence and control of black leg of cabbage. J. C. WALKER

Part of a seed bed sown at Madison, Wis., with infected seed and protected from rain showed 0.5 per cent infected plants after three months; that portion exposed to natural rainfall, 29 per cent; that frequently sprinkled, 39 per cent. Seed sown from same lot at La Conner, Wash., where dry weather prevailed, showed no disease after seven weeks. Rainy periods seem essential for dissemination of the fungus from primary centers. Correlation of rainfall and occurrence of disease in various localities indicates that weather conditions during growth of seed bed are extremely important in development of epiphytotics. The fungus is not entirely eradicated from infected seeds treated with 1–500 mercuric chloride for one hour; 1–128 formaldehyde for one hour; water at 55°C. for ten minutes; dry heat at 85°C. for seventy-two hours, 90°C. for forty-eight hours, 95°C. for twelve hours. Thus seed treatment within limits of injury to germination is not completely effective, and field observations show that proper weather conditions may still cause epiphytotics notwithstanding treatment.

Fifth progress report on Fusarium-resistant cabbage. L. R. JONES, J. C. WALKER, W. B. TISDALE.

Since last reported (Phytopath. 6: 102; Wis. Agr. Exp. Sta. Res. Bul. 38), the Wisconsin Hollander has maintained its character of relative resistance wherever tested and is now grown almost exclusively on the "cabbage sick" soils of Wisconsin. With the coöperation of a skillful grower (W. J. Hansche) an equally resistant earlier strain of Wisconsin Hollander has been selected. Resistant strains have also been perfected of two leading kraut varieties, All Seasons and Brunswick, and other promising variety selections started. In coöperation with the United States Dept. of Agric., Office of Cotton, Truck and Forage Crop Disease Investigations, and the National Kraut Packers Association, the problems of production and distribution of seed on a commercial scale are being met by growing limited quantities of "mother seed" in Wisconsin using heads carefully selected from "sick" soil, then sending this "mother seed" to the Puget Sound region for one generation increase. The output of seed is thus multiplied a thousand fold, insuring maximum commercial efficiency with minimum danger of loss of resistance. The Kraut Association is thus supplying the commercial needs in large kraut districts afflicted with yellows. The only danger foreseen is exploitation by some less scrupulous or intelligent commercial seed firms without strict attention to source of their mother seed.

Blossom blight of the peach. MEL. T. COOK

This disease, due to *Sclerotinia cinerea* (Bon.) Schrot. was much more severe in 1919 than usual. The crop on some trees was practically destroyed. The disease was much less severe on young than on old orchards, but there was no apparent connection with the mummified fruit or with varieties. The organism appeared to spread from the cankers on the 1918 wood. These cankers gave off gum and pro-

duced spores throughout the greater part of the growing season of 1919, but the fungus gradually became weaker and weaker. The cankers are evidently a very important source for the spread of the organism and apparently much more important than the mummied fruits. It is very doubtful if many of the cankers give off spores for more than one season. An important factor in control consists in preventing the formation of cankers. This can be done by more frequent and more thorough spraying.

A heart-rot of peach. W. A. McCUBBIN

A rot of the heart wood of living peach trees, occasionally met with prior to 1915, became very prevalent in the Niagara Peninsula in Ontario in 1916 and 1917. Numerous cultures indicate *Coriolus versicolor* (L.) Quel. as the causal organism. It is claimed that the fungus most readily attacks wood injured by winter conditions, and this view is upheld by evidence showing the restriction of the rot to those portions of the trunk and limbs in existence before the very hard winter of 1913–14 and severely injured at that time; and further by the occurrence in many cases, of two regions of rot separated by a cylinder of sound wood, the outer region associated with tissues injured in the afore-mentioned winter and the inner region associated with wood affected by the winter of 1911–12.

Changes of a decade in Plant Pathology. F. L. STEVENS

A brief summary of major events, introduced diseases, progress in disease resistance, taxonomic changes, significant facts, new plant diseases, and losses of personnel through death.

The development of Urophlyctis alfalfae. FRED REUEL JONES AND CHARLES DRECHSLER

The disease of alfalfa caused by *Urophlyctis alfalfae*, commonly known as crown wart, has been found to have its origin from the infection of very young buds, the foliar elements of which develop into abnormalities not involving the mature structures of root or stem. The thallus of the fungus consists of a succession of two types of structures, turbinate cells and resting spores. In the first turbinate cell that is the immediate development of the infecting fungus, are inserted a number of septa which delimit uninucleated peripheral segments from a central polynucleated central sporogenous mass. A hyphal structure of limited growth develops from each of these segments and carries the nucleus in its expanded termination, the latter constituting a young turbinate cell of the next succession. At its mature stage the turbinate cell bears a branched apical haustorium, the short axial element of which proliferates at its tip a globose terminal expansion into which the polynucleate sporogenous mass of protoplasm migrates to produce the resting spore. This is characterized by 10 to 15 branched haustoria in zonate arrangement between the equator and the distal pole. A solution of the thinner cell walls in próximity to the young advancing turbinate cells leads to the development of cavities in the hypertrophied tissue in which the resting spores are finally found enclosed.

Two destructive rusts ready to invade the United States. J. C. ARTHUR

A rust on peanuts has long been prevalent in South America. In Trinidad and the nearby islands of the Antilles it is a great menace to the crop, often covering every leaf on the plants with a heavy powder of urediniospores. No successful method of controlling the rust has yet been found. A rust on potatoes and toma-

toes, comparable in its life history and behavior with the hollyhock rust, has recently come to light in Costa Rica and Ecuador. The possibilities for its spread and harmfulness deserve serious attention. Neither this rust nor the preceding one has yet been reported from any United States possession.

Overwintering and control of bur clover leaf-spot. E. F. HOPKINS

Studies on the bur clover leaf-spot have shown that the causal fungus *Cercospora medicaginis* E. & E. is borne as mycelium on the seed within the burs. Seeds separated from the burs were found to contain a considerable number which showed dark markings on their surfaces. By disinfecting some of these seeds in mercuric chloride 1:1000 for thirty seconds, rinsing in sterile water, and planting in agar pure cultures of a fungus were obtained which in all cases appeared to be identical. Inoculations of healthy bur clover plants produced typical symptoms.

In attempting to determine the effect of boiling on the fungus with a view towards control, diseased seeds after being disinfected as above were planted in agar. It was found that boiling for as short a time as one-half minute would kill the fungus, while in the control cultures seeds which were disinfected but not boiled produced in each case a pure culture of Cercospora.

It is fairly certain from the above experiments and from microscopical examination that the mycelium occurs in the seed coats and that the fungus is not carried over, as Wolf has suggested (Phytopath. **6**: 301. 1916), by means of viable conidia on the burs.

A disease of red clover and strawberry in the Pacific Northwest caused by the nematode Tylenchus dipsaci (Kühn), Bastian. L. P. BYARS

The writer has observed in the Pacific Northwest during the past season a serious disease of red clover and strawberry plants caused by the nematode *Tylenchus dipsaci* (Kühn) Bastian, which has long been known to produce considerable trouble of many different species of plants in Europe. Although known to have been in the Pacific Northwest since its discovery at Bellingham, Washington, in 1913, the nematode has not been previously known to cause serious damage in this country.

On strawberry the disease may be recognized by pronounced local swellings of the leaves, petioles, stems, and stolons or fruiting branches, which contain the causal organism in all stages of development. Affected plants are usually dwarfed and contain a large number of adventitious branches.

Severely infected red clover plants may be recognized by blister-like swellings of the leaves, petioles, and stems, and by the terminal bending of the latter. Such plants usually have a sort of witches'-broom appearance, due to the production of adventitious primary branches.

While the nematodes causing the troubles on these two hosts seem to be morphologically alike, there is no certainty that they are physiologically identical.

Investigations of the disease in laboratory, greenhouse, and field are actively under way.

Flax canker, a non-parasitic disease. C. S. REDDY AND W. E. BRENTZEL

This paper deals with the type of flax canker which occurs somewhat uniformly. each year in the semiarid Northwest and causes a marked loss in flax production.

The cortex of the stem is killed at the surface of the ground. Sooner or later the plant topples over, but usually remains alive for days or weeks while the vascular system still functions. Usually the stem enlarges just above the injury and sometimes also just below. The result is a girdling of the plant at the soil line.

No parasitic organism has been found associated with this type of flax canker. Evidence seems to indicate that high temperature at the soil line during the early growth of the plant is the chief cause of the trouble. In preliminary experiments flax cankered only on and immediately following very hot days. It is susceptible only to a slight extent when more than four inches high. Plants shaded by a ten-inch vertical strip of canvas did not canker while unshaded plants in the same row cankered. Thickly sown flax cankered less than thinly sown flax. Flax sown with cereals cankered comparatively little, and flax with weeds cankered less than flax free from weeds. Killing the cortex of young flax plants by artificial heat produced typical flax canker.

Pythium as a causal factor in "pea blight." FRED REUEL JONES

The term "pea blight" as used by canners refers to several diseases of peas, but primarily to the retarded growth and death of plants consequent upon the decay of the stem below ground and more or less of the roots. In a number of localities in Wisconsin, Illinois, and Michigan selected for observation, where the disease is at its worst, several parasites have been found apparently contributing to produce this condition. Of these *Rhizoctonia solani*, a species of *Fusarium*, and *Pythium* (probably *debaryanum*) appear to be the more important. Under conditions prevailing in this region in 1919 Pythium appears to have been by far the most important, so that judged by this situation alone "pea blight" could be said to be primarily a Pythium problem. Under field conditions this fungus produces a typical "damping off" or wilt of occasional plants only, and in any case oospores have been rarely found in the diseased tissue.

Phoma root-rot of celery. C. W. BENNETT

In several instances, in the past few years, a Phoma root-rot, caused by *Phoma apiicola* Speg., has been found doing considerable damage to celery in Michigan celery-growing districts. This disease attacks the roots and bases of the plants, resulting in a rotting off of the roots near the crown or in the production of large black areas just beneath the surface of the soil. Moisture is the controlling factor in the restriction of the pathogene to the underground parts, and lack of oxygen is important in keeping the roots, which are deep in the soil, free from this disease.

In culture, the causal fungus develops a bluish to mouse-colored mycelium when first isolated from the host plant. After growing on certain media for a period, color is no longer produced. Under similar conditions the organism loses both its power to produce fruiting bodies and its parasitic potentialities.

Scientific instruments and patent rights. DONALD REDDICK

It is proposed that new species of scientific apparatus for use in pathological work should be submitted to a committee of specialists for examination and test. When favorable reports are returned to the American Phytopathological Society Incorporated, the corporation should take out patent rights and market the product either by sale outright or on a royalty basis. This would insure that useful apparatus would be immediately available to all workers. The burden of the royalty no doubt would fall on the institutions, but it would be relatively insignificant. Any revenue from royalties would belong to the "Corporation" and might be used to further scientific research.

Studies on varietal resistance and susceptibility to bacterial blight of the soy bean.
C. M. WOODWORTH AND FLORENCE COERPER BROWN

Field observations and experiments at the University of Wisconsin during the past three or four years have indicated that soy bean varieties vary greatly in their relative susceptibility to the bacterial blight. Of 47 varieties secured from the Agricultural Experiment Stations of Illinois, Ohio, Indiana, Kentucky and Wisconsin, and grown in 1918, about half were completely resistant and the other half ranged from complete susceptibility to partial resistance. Experimental inoculations in the greenhouse have strengthened this evidence regarding varietal differences in resistance. Varieties Ebony, Elton, Habara, No. 8 (S. P. I. No. 20406), Mammoth yellow, Virginia, Cloud, Wilson, Medium yellow, and Ito San were under trial. All plants were sprayed with a water suspension of the bacterial blight organism shortly after the first compound leaf appeared. An examination made three weeks later showed about half of the plants of the Wilson variety, all but three of Medium yellow and all of Ito San, infected. The other varieties were completely resistant.

LITERATURE ON PLANT DISEASES[1]

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All authors are urged to cooperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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